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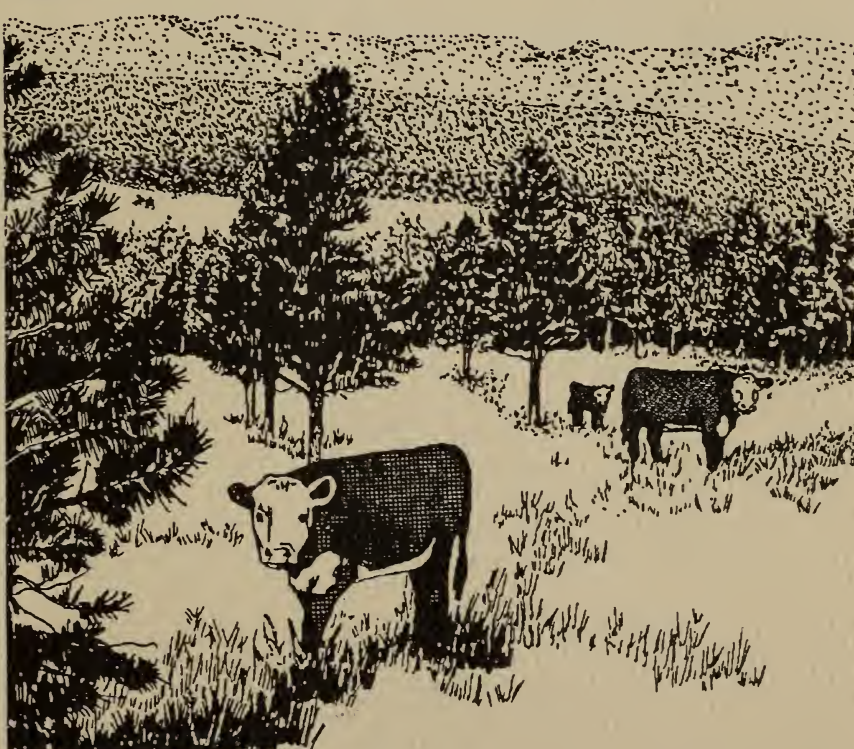
Can Livestock Be Used as a Tool to Enhance Wildlife Habitat?

Reno, NV, February 13, 1990



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Can Livestock Be Used as a Tool to Enhance Wildlife Habitat?

43rd Annual Meeting of the Society for Range Management

Reno, NV, February 13, 1990

Kieth E. Severson[1]
technical coordinator

[1] *Supervisory Range Scientist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, at the Station's Research Work Unit in Tempe, in cooperation with Arizona State University. Station headquarters is in Fort Collins, in cooperation with Colorado State University.*

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Introduction to the Symposium: Can Livestock Be Used as a Tool to Enhance Wildlife Habitat?

Kieth E. Severson[1]

Using livestock to manage wildlife habitat is not new a idea. Aldo Leopold (1933) stated, "Cover is controlled by controlling the plant succession in the right direction at the right time and place. Cow, plow, axe, and fire reverse succession. Fencing, fire-protection, and planting advance it." Leopold also referred to these as "tools." Well into the first half of this century, these "tools" were considered to adversely affect populations of native animals, and have been blamed on contemporary scientists and managers for current problems.

Unrestricted tree harvesting and grazing, wildfires, and plowing non-arable lands have created a multitude of resource management problems. However, three of these have evolved into recognized and accepted tools. Managed timber harvesting, prescribed fire, and plowing (including its rangeland counterparts: brush crushing, bulldozing, chaining, etc.) are used to manage wildlife habitats throughout the West. Grazing, however, has not been granted this status. Although some research has been done on using managed livestock grazing as a silvicultural tool in the northwestern and southeastern parts of the United States, livestock grazing still is largely regarded as detrimental to wildlife habitats.

Livestock-wildlife interactions have drawn the attention of managers and researchers in the West for almost a century. About 35 years ago John Hall (1955), then Director of the Arizona Game and Fish Department, stated,

> "The problem of Livestock versus Wildlife has plagued us since the turn of the century...Instead of decreasing in intensity, this battle has become broader and more bitter as the years go by. It would seem that as we learn

[1] *Supervisory Range Scientist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, stationed at Arizona State University, Tempe, AZ 85287.*

more about the proper management of both livestock and wildlife on our ranges, some progress would be made towards solving the problem of conflicting use."

A conflict that was once primarily centered on deer/elk/sheep/cattle and confined to the West has expanded to include all forms of wildlife and has become a national concern, despite an increasing knowledge base.

We know that livestock can influence the vegetation by altering its composition, productivity, and structure. Unfortunately, most examples emphasize the negative aspects of livestock presence, typified by the onerous and often misunderstood term "overgrazing." Most pointed references to the damaging effects of livestock on wildlife habitat have been derived from situations involving heavily or severely overgrazed ranges. As a result, much research has been directed at mitigating damaging effects or assessing competitive interactions.

However, if livestock influence vegetation, are there situations where these responses could be manipulated to create habitat conditions that result in favorable or positive responses by wild species? Leopold (1933) suggested this nearly 60 years ago, and Smith (1949) provided an excellent example of how grazing/browsing by one class of animal could improve habitat conditions for another.

These proceedings consist of six papers that discuss some of what is known about using livestock as a tool to improve wildlife habitats. Not all papers report results based on data; some present a series of hypotheses based on other studies or historical records of natural and human-induced disturbances. The symposium was not intended to solve the problem of livestock/wildlife interactions on rangelands, or to exonerate the practice of grazing livestock. Its purpose was to present a new, positive approach to livestock/wildlife interactions.

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Summary: Livestock Grazing as a Wildlife Habitat Management Tool

Kieth E. Severson[1]

Most of the papers presented tended to address the premise that livestock could be used to improve wildlife habitats, with a series of positive, yet cautious, strategies. The strategies developed were in four general categories:

1. Alter the composition of the forage base; that is, change the proportions of plant species present and perhaps cause the introduction of others.

2. Increase the productivity (available forage) of selected species in the forage base.

3. Increase the nutritive quality of the forage.

4. Alter the structure of vegetation.

In response to those who view the idea of using livestock as a tool to manage habitats as a panacea for all livestock/wildlife related problems, Philip Urness, in his oral presentation, said that the concept of using livestock as a tool is not God's gift to solving wildlife/livestock interaction problems. Indeed, it's applications may be very limited.

For example, in my personal experience, which has been divided between the northern Great Plains and the varied habitats of the American Southwest, it is easier to visualize how livestock could be used to manage vegetation in the Northern Great Plains. The primary reason is that the vegetation of the Plains evolved under significant grazing pressure by large ungulates; whereas that in the Southwest did not. The logic employed by Kantrud (these proceedings) in his assessment of using prescribed cattle grazing and prescribed fire as replacements for bison and wildfire, to manage waterfowl

[1]*Supervisory Range Scientist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, stationed at Arizona State University, Tempe, AZ 85287.*

habitat in the Prairie Pothole region of the Great Plains, is correct for that region. However, the same logic should be cautiously applied to other regions, such as the mountain wetland "cienagas" of the Southwest.

Not all sites lend themselves to manipulation by grazing. If the site is particularly fragile because of climatic or soil conditions, even a small regressive change could cross a threshold from which recovery (in a realistic temporal sense) is not possible. In these cases, livestock may not be an appropriate tool to consider.

Although livestock grazing seldom destroys wildlife habitats, it does alter them. Kie and Loft (these proceedings) emphasized that grazing-induced changes in structure and composition of plant communities can benefit some wildlife species while adversely affecting others. A prescribed grazing program, designed to enhance habitats for a particular wildlife species, is likely to affect some other species negatively. Planning must consider such tradeoffs. A case in point, involving mule deer and elk, is discussed by Urness (these proceedings). Guthery et al. (these proceedings) also implied this by stating that the use of short duration grazing systems in managing habitat will vary with the target species.

Those who consider the concept of using livestock grazing as a tool as an attempt to camouflage past and current mismanagement are urged to view this in the actual context of the papers presented. Every presentation in these proceedings emphasizes the need for establishing specific goals and developing specific management plans to achieve those goals. Planning considerations involve timing of grazing relative to season and plant phenology, attaining precise utilization levels on some species while avoiding use on others, development of new or modification of existing grazing systems, and determining specific tradeoffs (i.e., what other species will be affected and to what degree).

There are organizations and individuals, considered strong environmentalists, that have recognized beneficial aspects of grazing. For example, Ted Williams, in a commentary on effects of government programs on pothole draining, which appeared in the September 1989 issue of *Audubon*, the magazine of the National Audubon Society, stated; "Filling the vacant niche of bison, the cattle keep emergent vegetation from choking out waterfowl habitat....Unmolested by bovine teeth, cat-

tails force the ducks from the deeper, undrainable potholes." Aldo Leopold (1933) deplored the fact that damage done to wildlife by overgrazing was little appreciated by the public, yet recognized that livestock grazing could be used as a tool to manage wildlife habitat.

Managing wildlife habitat is expensive. Increasing labor and fossil fuel costs have negated the use of mechanical methods (e.g., root plowing, reseeding, etc.), except in special circumstances. Chemical methods, such as fertilizers and herbicides, also are expensive and generate adverse side-effects on other facets of the environment. Fire is a useful tool, but applications are limited by potential air pollution and the necessity for exact conditions. Livestock grazing would not be intended to replace any existing methods, and would have its own limitations, but could provide an alternative or additional tool, such as with fire (Kantrud, these proceedings).

Two other points should be noted. One is that we did not consider, specifically, what the effects would be on milk/meat/wool production if the domestic animals were being manipulated to improve wildlife habitat, although it was discussed by Sedivec et al. (this symposium). This is an important consideration. It is unlikely that a manager could convince a private landowner or a permittee to use a method of grazing that would enhance wildlife habitat if it resulted in decreased livestock production. This may not always be the case, however. A state game agency or public land manager could have the option of leasing a herd specifically to manage vegetation on a wildlife habitat unit. Here, the lessor may be expected to accept a loss in animal production if it was accounted for in the lease agreement. Either way, it is essential to know what the effects on livestock would be.

The second point is that the term "overgrazing" has been used in several of these papers. This term is almost always used with a negative connotation, with certain justification. When we talk about altering the vegetative composition of a site by manipulating livestock, that is, changing the proportions and kinds of species, we are advocating overgrazing. However, this is a relative term. A lightly or moderately overgrazed range may have only slightly different proportions of the plant species normally present on an undisturbed site, while a heavily overgrazed range may have a completely different species composition.

Urness (these proceedings) states that overgrazing of competitive perennial grasses and forbs may be desirable and necessary to attain or maintain a good mixed community that includes a vigorous shrub component. He further suggests that overgrazing is bad only if it leads succession away from the management objective or if it degrades site integrity. This illustrates the importance of knowing what the successional processes and potential thresholds are on each site in question before proceeding with a prescribed grazing program.

Although there are a variety of opinions on the validity of using livestock as a tool to enhance wildlife habitats, the present state of knowledge is quite meager and essentially limited to the discussions presented here. Researchers and managers have a clear responsibility to further define where and how it can be used, as well as to determine under what circumstances it cannot or should not be used. However, enough evidence is available to warrant its application in some areas and certainly to investigate its applicability in others.

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Using Livestock to Manage Wildlife Habitat: Some Examples from California Annual Grassland and Wet Meadow Communities[1]

John G. Kie[2] and Eric R. Loft[3]

Abstract.—Livestock can be used to manage wildlife habitat in some cases. For example, in the absence of grazing, California annual grassland communities are dominated by dense stands of tall grasses. Livestock grazing reduces plant height and biomass, and encourages the growth of forbs. With grazing, habitat value to wildlife species that require forbs as a forage source is increased, and value to species dependent on dense herbaceous growth is decreased. Less dramatic changes can occur in Sierra Nevada wet meadow communities as a result of grazing. Livestock can open up dense stands of shrub vegetation such as willow thickets and improve access for several species of wildlife through trampling and browsing. In wet meadows, grazing can result in either an increase or a decrease in the abundance of forbs. Important factors to consider in prescribing grazing for wildlife habitat improvement include: wildlife species of concern, timing of grazing, livestock numbers, and management objectives.

Introduction

Livestock grazing can be used to manipulate habitat for various wildlife species under some conditions (Holechek et al. 1982, Urness 1982). Generally, there are three ways livestock

[1]*Paper presented at the Forty-third Annual Meeting of the Society for Range Management symposium: Can livestock be used as a tool to enhance wildlife habitat? (Reno, Nevada, February 13, 1990).*
[2]*John G. Kie is Research Wildlife Biologist, U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, 2081 East Sierra Avenue, Fresno, CA 93710.*
[3]*Eric R. Loft is Wildlife Biologist, California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814.*

influence wildlife habitat: (1) by modifying plant biomass, (2) by modifying structural components such as vegetation height and cover, and (3) by modifying plant species composition. However, the relationship between grazing and wildlife habitat values appears to be complex and highly variable. For example, following the establishment of a wildlife management area in northeastern Oregon and the exclusion of cattle in 1961, elk *(Cervus elaphus)* numbers increased from 120 to about 320 animals (Anderson and Scherzinger 1975). A resource management plan implemented in 1964 included a cattle-grazing system designed to increase winter forage quality for elk. By 1974, over 1,100 elk were counted on the area (Anderson and Scherzinger 1975). In addition, elk and red deer *(Cervus elaphus)* have been shown to prefer feeding areas that previously have been grazed by cattle (Grover and Thompson 1986, Gordon 1988).

Conversely, an attempt to use spring cattle grazing as a tool to increase winter use of a bunchgrass foothill range in southeastern Washington by elk was unsuccessful, and actually resulted in a 28% decrease in elk use during one of three years studied (Skovlin et al. 1983). Another study reported no effect of summer cattle grazing on quality of winter forage for elk in Montana (Dragt and Havstad 1987).

Despite apparent inconsistencies, livestock grazing has been suggested as a tool to improve habitats for wildlife species as diverse as mule deer *(Odocoileus hemionus)* (Smith et al. 1979, Willms et al. 1979, Reiner and Urness 1982), northern bobwhites *(Colinus virginianus)* (Moore and Terry 1980), and Canada geese *(Branta canadensis)* (Glass 1988). In this paper, we suggest several factors that should be considered before implementing a grazing program to manage wildlife habitat: wildlife species of concern, timing of grazing, livestock numbers, and management objectives. To illustrate these points, we use examples from annual grassland and wet meadow habitats in California.

Wildlife Species of Concern

Grazing-induced changes in the structure and composition of plant communities can benefit some wildlife species while adversely affecting others. A grazing program can be designed

to maintain or enhance habitat values for a particular wildlife species or group of species, but invariably, some other species will be negatively affected. A thorough understanding of wildlife species' habitat needs and limiting factors is important for developing an appropriate grazing program.

Annual Grassland Habitat

Annual grassland habitats in California are composed primarily of annual plant species, many of which also occur as understory plants in oak woodland and other habitats. These species germinate with the first fall rains that exceed about 15 mm (0.6 in), growing slowly during winter and rapidly in spring (Heady 1977). Most annuals mature between April and June (Heady 1977), although some species, such as turkey mullein *(Eremocarpus setigerus)*, continue to grow into summer.

Livestock grazing can favor the growth of low-stature, spring-maturing forbs, such as filaree (*Filaree* spp.), and summer annuals, such as turkey mullein. In the absence of livestock, annual grassland habitats are often dominated by tall, dense stands of grasses such as ripgut brome *(Bromus diandrus)* and wild oats (*Avena* spp.) (Kie 1988).

We used the computerized California Wildlife Habitat Relationships (WHR) database as a starting point to help predict the effect of livestock grazing on vertebrate wildlife species. The WHR program provides information such as a computer database describing habitat classification, wildlife species list, and distribution maps (Mayer and Laudenslayer 1988). The WHR habitat classification recognizes two stages or structural conditions of annual grassland habitat (short-herb and tall-herb) using an arbitrary mature plant height criteria of greater or less than 30.5 cm (12 in). The database then rates various plant density classes within each of these two structural conditions as habitat for different wildlife species.

We used the WHR habitat capability models assuming that the primary effect of livestock grazing would be to reduce average plant height from a tall-herb to a short-herb structural class. In general, such a reduction would have a positive effect on 52 wildlife species, no effect on 171 species, and a negative effect on 29 species (table 1). In general, birds and reptiles would be favored by short-herb structural conditions, while mammals and amphibians would be adversely affected

(table 1). However, the response depends on the individual species (table 2).

In addition, the WHR database lists 84 vertebrate wildlife species (23 birds, 57 mammals, and 4 reptiles) that feed in annual grassland habitats and show an affinity for forbs as special habitat elements (table 3). Livestock can be used to improve habitat values for these species by providing a mix of grasses and forbs in the herbaceous plant community.

Table 1.—Numbers of wildlife species using California annual grassland habitat affected by reduction from tall-herb to short-herb structural conditions as a result of livestock grazing.

Class	Positive effect	No effect	Negative effect
Birds	44	61	18
Mammals	2	84	8
Amphibians	0	5	3
Reptiles	4	21	0
Total	50	171	29

Table 2.—Examples of some wildlife species using California annual grassland habitat affected by reduction from tall-herb to short-herb structural conditions as a result of livestock grazing.

Positive effect	Negative effect
Birds	
Horned lark *(Eremophila alpestris)*	Song sparrow *(Melospiza melodia)*
Black-bellied plover *(Pluvialis squatarola)*	Common barn owl *(Tyto alba)*
European starling *(Sturnus vulgaris)*	Ring-necked pheasant *(Phasianus colchicus)*
Canada goose *(Branta canadensis)*	Mallard *(Anas platyrhynchos)*
Mammals	
Axis deer *(Cervus axis)*	Brush rabbit *(Sylvilagus bachmani)*
Fallow deer *(Cervus dama)*	Striped skunk *(Mephitis mephitis)*
Amphibians	
None	Western spadefoot toad *(Scaphiopus hammondi)*
	Tiger salamander *(Ambystoma tigrinum)*
Reptiles	
Western fence lizard *(Sceloporus occidentalis)*	None
Western aquatic garter snake *(Thamnophis couchi)*	

Wet Meadow Habitat

Wet meadow communities in California and elsewhere have been an important source of summer forage for domestic livestock since the 1860's (Burcham 1957, Ratliff 1985). They are also vital to many species of wildlife, and are becoming increasingly important for other uses such as watershed and recreation.

In wet meadows, cattle grazing can slow or reverse plant succession (Leege et al. 1981). Tunnels and browseways in shrub vegetation result when cattle forage in the shrub canopy, primarily after most herbaceous forage has been consumed (Knopf and Cannon 1982, Roath and Krueger 1982, Loft et al. 1987, Knopf et al. 1988). This modification of structural diversity and opening of shrub stands can be a benefit to some wildlife species (Leopold et al. 1951, Krueger and Anderson 1985).

Wet meadows occur in the mountains of California from the Cascades to the Sierra Nevada and in scattered locations in the southern part of the state (Ratliff 1988). They are comprised of a variety of perennial grasses, sedges, and forbs. Woody plant species such as willow (*Salix* spp.), alder (*Alnus*

Table 3.—Examples of some wildlife species using California annual grassland habitat showing an affinity for forbs as specific habitat elements.

Birds	Mammals
Greater white-fronted goose *(Chen albifrons)* Ross goose *(Chen rossii)* Northern pintail *(Anas acuta)* Chukar *(Alectoris chukar)* Turkey *(Meleagris gallopavo)*	California ground squirrel *(Spermophilus beecheyi)* Botta's pocket gopher *(Thomomys bottae)* Western pocket gopher *(Thomomys mazama)* Mule deer *(Odocoileus hemionus)* California quail *(Callipepla californica)*
Amphibians	**Reptiles**
None	Side-blotched lizard *(Uta stansburiana)* Western pond turtle *(Clemmys marmorata)*

spp.), and aspen *(Populus tremuloides)* are associated with meadow communities. Grazing usually occurs summer-long for about three months. Cattle are most common, with sheep numbers being lower than in past decades. Cattle grazing can reduce grass and grasslike species abundance in the herbaceous community and increase forb abundance (Ratliff 1988). Unlike the annual grassland habitat, however, ungrazed mountain meadows often have an abundant forb component (Bowns and Bagley 1986).

Using the WHR database and making the same assumption that livestock grazing in wet meadows will act to reduce tall-herb communities to ones dominated by short herbs, similar results were obtained. More birds and reptiles are favorably affected by reductions in plant height than are adversely affected (table 4). Most mammals and amphibians are either not affected or are adversely affected. Some of the same wildlife species affected in annual grasslands are also affected in wet meadows (table 5).

As mentioned previously, the WHR database should only be used as a first approximation for such comparisons. The outputs require close scrutiny for potential errors based on faulty assumptions or actual errors in the database itself. For example, montane voles *(Microtus montanus)* and western harvest mice *(Reithrodontomys megalotis)* were listed by the database as benefited by changes in wet meadow habitats from tall-herb to short-herb structural conditions (table 5). However, both species are highly dependent on dense herbaceous cover to avoid predators, and additional reductions below 30.5 cm (12 in) in plant height resulting from livestock grazing would adversely affect these species. In fact, most livestock grazing programs would probably either not affect or actually reduce their numbers.

Table 4.—Numbers of wildlife species using California wet meadow habitat affected by reduction from tall-herb to short-herb structural conditions as a result of livestock grazing.

Class	Positive effect	No effect	Negative effect
Birds	53	71	26
Mammals	2	72	9
Amphibians	1	16	2
Reptiles	3	10	0
Total	59	169	37

Sixty-eight wildlife species (25 birds, 41 mammals, 1 amphibian, 1 reptile) in wet meadow communities show an affinity for forbs as specific habitat elements (table 6). However, livestock grazing is less important in wet meadows than in annual grasslands in providing a rich mix of forbs in the herbaceous cover, and many of these wildlife species would not necessarily be benefited by grazing. Heavy grazing by sheep over long periods can reduce the abundance of forbs in some mountain meadow communities (Bowns and Bagley 1986).

Table 5.—Examples of some wildlife species using California wet meadow habitat affected by reduction from tall-herb to short-herb structural conditions as a result of livestock grazing.

Positive effect	Negative effect
Birds	
Killdeer *(Charadrius vociferus)* Wilson's phalarope *(Phalaropus tricolor)* Chukar *(Alectoris chukar)*	Song sparrow *(Melospiza melodia)* Common barn owl *(Tyto alba)* Willow flycatcher *(Empidonax traillii)*
Mammals	
Montane vole *(Microtus montanus)*[1] Western harvest mouse *(Reithrodontomys megalotis)*[1]	Raccoon *(Procyon lotor)* Beaver *(Castor canadensis)* Striped skunk *(Mephitis mephitis)*
Amphibians	
Yosemite toad *(Bufo canorus)*	Northern leopard frog *(Rana pipiens)* Pacific giant salamander *(Dicamptodon ensatus)*
Reptiles	
Common garter snake *(Thamnophis sirtalis)* Western aquatic garter snak *(Thamnophis couchi)*	None

[1]*These two species of mammals, although listed by the WHR database as being benefitted by a reduction from tall-herb to short-herb structural conditions, would actually be adversely affected by most livestock grazing systems.*

Previous work in the Sierra Nevada has shown that cattle grazing also can reduce the absolute abundance of forbs in wet meadows (Winckel 1989). Depending on the timing and intensity of grazing, wildlife species showing an affinity for forbs as special habitat elements in wet meadows may be either positively or negatively affected.

Timing of Livestock Grazing

Timing of livestock grazing is an important factor to consider when designing a grazing program to enhance wildlife habitat values. Range ecologists have realized for years that defoliation of plants by grazing animals will have different effects on plant vigor and reproduction depending on the life stage of the individual plants. Such knowledge is the basis for a variety of specialized grazing systems.

Just as the timing of livestock grazing can be manipulated to achieve a desired successional stage for maximizing livestock forage production, it can be used to reach other successional stages to benefit certain groups of wildlife species. Furthermore, livestock grazing programs designed to benefit wildlife need to consider potential conflicts with critical periods in the

Table 6.—Examples of some wildlife species using California wet meadow habitat showing an affinity for forbs as specific habitat elements.

Birds	**Mammals**
Greater white-fronted goose *(Chen albifrons)* Ross goose *(Chen rossi)* Northern pintail *(Anas acuta)* Mountain quail *(Oreortyx pictus)*	Golden-mantled ground squirrel *(Spermophilus lateralis)* Botta's pocket gopher *(Thomomys bottae)* Porcupine *(Erethizon dorsatum)* Mule deer *(Odocoileus hemionus)*
Amphibians	**Reptiles**
Black-toad *(Bufo exsul)*[1]	Western pond turtle *(Clemmys marmorata)*

[1] *The black toad is officially listed by the state of California as rare, and by the U.S. Forest Service and BLM as a sensitive species.*

life cycles of the wildlife species. Destruction of bird nests and loss of hiding cover for newborn animals are two examples of such conflicts.

Annual Grassland Habitat

As mentioned previously, livestock grazing in annual grassland habitat reduces dense stands of tall grasses and encourages the growth of low-growing forbs. Annual grasslands are often grazed from early fall through late spring, with cattle going to higher elevation leased allotments during the summer months. However, some annual grasslands are grazed yearlong. Cattle are usually fed supplemental nutrients in the form of cottonseed meal, alfalfa, or commercial molasses and urea mix during the dry summer months (July-October) and the winter months (October-January) when forage standing crop is low (Dunbar et al. 1988).

The critical time of the year for wildlife in the annual grassland habitat depends again on individual wildlife species. Migratory mule deer, for example, often winter in annual grassland and associated habitats such as blue oak *(Quercus douglasii)* woodlands. Deer diets in November and December may contain as much as 20% grasses in this habitat (Leach and Hiehle 1957). Heavy livestock stocking rates, supported by a supplemental feeding program, during the time when herbaceous forage is in short supply likely have a negative effect on deer.

Also, acorn drop in blue oak and black oak *(Quercus kellogii)* woodlands occurs during the months of October and November (Bowyer and Bleich 1979, Menke and Fry 1979). Acorns are high in digestible energy (Harlow et al. 1975), and competition for them can be high between some bird species, deer, sheep, and cattle. In some years, the entire acorn crop may be consumed in a few weeks (Bowyer and Bleich 1979).

A livestock management program designed to optimize benefits for mule deer would eliminate grazing during the fall and early winter months to allow deer noncompetitive access to herbaceous forage and acorns. Conversely, grazing would be implemented in late winter and spring to reduce the abundance of grasses and encourage the growth of forbs. An example of such a program occurs on the 44,110-acre Tehama Wildlife Management Area in northern California, where cattle

grazing is administered by the California Department of Fish and Game under leases that run from 15 March to 15 May each year.

Grazing in late spring when annual plant growth is rapid is beneficial to mule deer because forb growth is encouraged. Grazing when annuals have matured and dried, however, may increase livestock use of desirable browse and cover species. Livestock may also concentrate in and damage valuable riparian habitats in early summer once plants on other upland sites have matured.

Wet Meadow Habitat

On summer ranges, cattle tend to congregate in riparian and meadow areas where herbaceous vegetation remains lush and palatable for most of the season (Leege et al. 1981, Roath and Krueger 1982, Loft et al. 1987). During early to mid-summer, cattle use of shrubs is usually low because of the availability of high quality herbaceous forage. During late summer, when herbaceous vegetation in open meadow areas has matured or been consumed, cattle increasingly spend more time feeding on woody vegetation such as willow and aspen.

The grazing period on wet meadows begins between late June and mid-July in California and may continue until early fall. The objective for using cattle to benefit wildlife in meadow communities involves keeping the cattle from congregating in meadow areas summer-long. Many species, such as mule deer, give birth to their young in early summer. By delaying cattle grazing until about mid-summer, cover and forage can increase and be maintained. Grazing can then be used to create disturbance in the herbaceous and shrub vegetation.

Cattle can significantly reduce cover necessary to deer fawns during summer (fig. 1) (Loft et al. 1987). By delaying the on-date for grazing, disturbance to deer hiding cover can be minimized, and fawn survival will likely be higher than in areas grazed season-long.

While cattle grazing provides benefits to some wildlife species, such treatment would not be necessary every year to achieve the maximum level of benefits. A rest-rotation grazing system, with either one or two years rest out of three on a three-pasture system would likely yield greater benefits to wildlife than continuous, season-long grazing every year.

Some trade-offs exist in implementing such a rotation grazing scheme, however. Total cattle numbers over the three-pasture system would have to be reduced. At both moderate and heavy stocking rates, cattle tend to congregate in wet meadow communities and have similar effects on herbaceous standing crop and deer hiding cover. However, at high stocking rates, cattle have a greater impact on the structure of willow stands (Loft et al. 1987).

Livestock Numbers

Livestock numbers and stocking rate are important variables in any grazing management program. Traditional definitions of proper grazing are based on the concept of maintaining a good mix of advanced-successional stage species in the plant

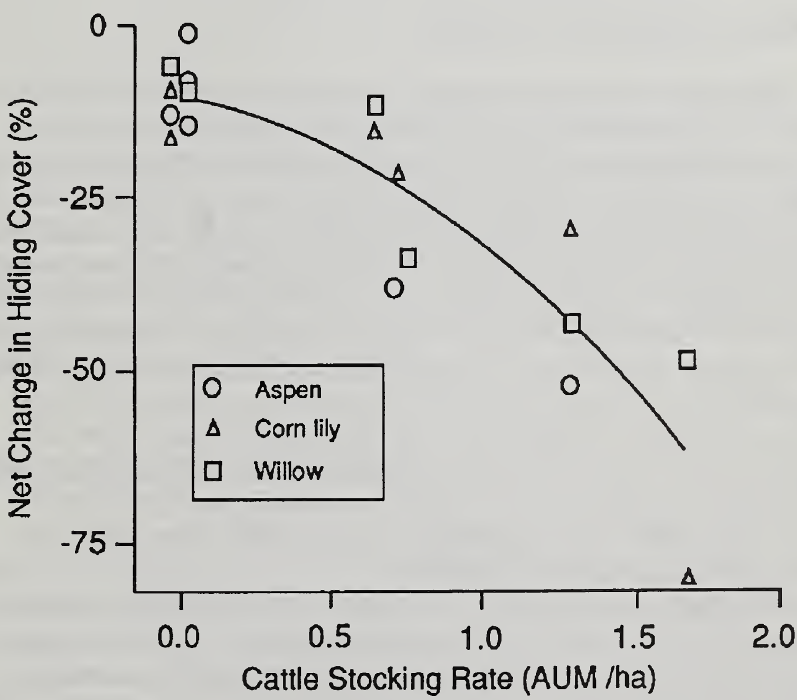

Figure 1.—Net change in hiding cover at mid-summer in aspen (*Populus tremuloides*), corn lily (*Veratrum californicum*), and willow (*Salix* spp.) vegetation types within wet meadow habitats as a function of cattle stocking rate (after Loft et al. 1987).

community. These are referred to as decreasers because of their tendency to decrease in abundance with increasing livestock grazing pressure (Dyksterhuis 1949). Proper grazing to achieve wildlife habitat management objectives may dictate a livestock stocking rate very different from that based upon the traditional range management definition. Appropriate rates could conceivably be heavier than otherwise for a brief period of time if the goal were to retard succession to an early seral stage. The rates could also be lighter than usual based on criteria such as providing abundant hiding and escape cover for wildlife.

Desired livestock numbers to benefit wildlife depends upon the distribution of forage resources and movement patterns of the livestock. Patchily-distributed, high-quality habitat such as stringer meadows may be severely impacted by livestock while large, open herbaceous meadows would result in wider distribution of animals and a lesser impact.

Annual Grassland Habitat

Traditional concepts of range condition and trend (Dyksterhuis 1949, Stoddart et al. 1975) are not applicable to annual grassland habitats (Smith 1978, 1988; Kie and Thomas 1988). Because much of the herbaceous community is dominated by introduced annual plants, range condition is always classified as poor under those concepts. Instead, annual grassland ranges are managed for residual dry matter (Clawson et al. 1982). The goal is to leave sufficient residual dry matter at the end of the summer to provide a favorable microenvironment for seedling germination and growth in the fall, and to prevent soil erosion. Minimum residual dry matter standards vary from 225 kg/ha (200 lb/ac) on flat slopes with less than 25 cm (10 in) of annual precipitation to as much as 1,400 kg/ha (1,250 lb/ac) on steep slopes where precipitation exceeds 100 cm (40 in) annually (Clawson et al. 1982).

Although plant material not eaten by livestock is available for use by vertebrate wildlife species and invertebrate decomposers (Clawson et al. 1982), stocking rates based on residual dry matter standards usually are compatible with wildlife habitat management goals. In annual grasslands, timing of livestock grazing may be of greater concern to wildlife managers than livestock numbers based on residual dry matter stan-

dards, although both factors are important in providing habitat for some wildlife species.

Wet Meadow Habitat

On wet meadow habitats, monitoring of cattle typically involves estimates of utilization of meadow forage at or near the end of the grazing season. However, there may be little difference in utilization of meadow forage from year-to-year despite a varying level of productivity (Loft et al. 1987). The goal of grazing to benefit wildlife is to influence vegetation structure, biomass, or species composition. A possible way to sustain wildlife values is to monitor cattle impact on the shrub community. Cattle prefer to forage in open meadows when herbaceous forage is available, but move into shrub stands, such as willow, when forage availability declines (Loft et al. 1987). By monitoring impacts on the shrub community, cattle can be removed when that impact becomes undesirable. Hence, cattle numbers can be used to create and maintain openings in shrub stands as desired.

Cattle stocking rates for good range livestock management are unfortunately not always the most desirable stocking rates for good range wildlife management. For example, recommended livestock stocking rates based on traditional range management objectives might average 0.5 AUM/ac for wet meadows in good condition at 7,000 ft (2,100 m) in elevation (Ratliff et al. 1987). However, to maintain adequate hiding cover for mule deer fawns, stocking rates should be limited to 0.2-0.3 AUM/ac (Loft et al. 1987).

Management Objectives

Management objectives obviously play a part in any livestock management program. The relative emphasis placed on providing livestock forage versus meeting habitat management goals for certain wildlife species must be evaluated. Land ownership, alternative land uses, grazing system constraints, wildlife value for hunting or viewing, species status under the Endangered Species Act or other state or federal agency designation (table 6), and other factors all play a role in determining specific management objectives.

Some areas are managed to maximize sustained livestock productivity, while some are managed to maximize wildlife values. It is becoming increasingly apparent that while good range management can provide for good wildlife habitat, the best wildlife habitat often requires modifications of existing livestock management practices.

Annual Grassland Habitat

Most annual grassland habitat in California is in private ownership, and provides base property for permittees who graze their cattle on higher elevation allotments during the summer. Although such grazing practices may be less than optimum for providing herbaceous forage and acorns for deer and other wildlife species, they have been the status quo for a century or more in most cases. Some deer herds are doing well under that strategy.

Residential development is occurring at a rapid rate in annual grassland and other California foothill habitats. Current ranching practices on private land that follow sound residual dry matter guidelines are preferable to subdivision and development for almost all wildlife management objectives.

In areas where annual grassland habitats are managed by state or federal agencies, a greater attention to maximizing wildlife habitat objectives may be appropriate. Furthermore, under California's Ranching for Wildlife program, where private land owners are authorized extended hunting seasons in return for improving wildlife habitat, modification of existing grazing practices is an option worth considering.

Wet Meadow Habitat

Contrary to the majority of annual grassland, most of the wet meadow communities in California are public lands. The difficulty in managing cattle on summer range focuses on avoiding overgrazing of preferred habitats such as meadows and riparian areas. Achieving the desired distribution of cattle may be difficult because meadows usually can provide forage season-long and have water nearby. Additionally, there is growing opinion that grazing of meadows is completely deleterious and should be halted in favor of wildlife, watershed, and recreation use benefits. Grazing of meadow communities

can be used to help maintain long-term productivity and condition, but to conform to the probable demands of the future, must avoid detrimental impacts. Livestock can be manipulated by timing their presence, numbers, and distribution to achieve wildlife goals. To do so takes considerable cooperative effort, but examples of such cooperation are increasing.

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Livestock as Manipulators of Mule Deer Winter Habitats in Northern Utah[1]

P. J. Urness[2]

Abstract.—Livestock grazing at heavy intensity starting after 1850 and fire suppression created dense shrub-dominated communities on much foothill rangeland in the northeastern Great Basin. Successional change favoring woody plants and regulated exploitation of game animals had, by mid-twentieth century, yielded large increases in mule deer populations. Subsequent reduction or outright removal of livestock set in train a reversion to the former ecological condition and decreased deer-carrying capacity along the Wasatch Front. Research has shown that carefully managed grazing by cattle, sheep, horses or goats can retain or restore deer habitat values, but land managers have been unable or unwilling to make that commitment. Therefore, future declines in deer populations can be expected, even where urbanization and cropland agriculture are not the problem.

Presettlement vegetation on foothill ranges in the northeastern Great Basin and elsewhere in the region was apparently dominated by perennial grasses and forbs, with variable densities of shrubs likely influenced by time since the last fire (Pickford 1932, Stewart 1941, Hull and Hull 1974). Mule deer were scarce and remained so well into the 20th century, despite successional changes favoring shrubs and trees as early as 1880, because of unregulated hunting (Leopold 1950, Wagner 1978, Gruell 1986). These successional changes were initiated

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[2]*Philip J. Urness is Professor of Range Science, Utah State University and Research Biologist, Utah Division of Wildlife Resources, Logan.*

by heavy grazing of livestock accompanied by reductions in fire frequency. Heavy grazing continued on most areas up to the 1930's and in some areas even later. Once protective regulations were instituted in the early 1900's, mule deer were able to take advantage of increased carrying capacities on winter range and populations built rapidly in the 1930-50 period under conservative hunting (Julander 1962).

Excessive deer populations, contributing to further abuse of ranges already degraded by past livestock practices, led to liberalization of hunting around 1950 against strong resistance. Liberal hunting continued for a quarter century with fairly stable populations until the mid 1970's when a brief decline led to resumption of conservative hunting regulations that have persisted to the present time.

There are indications that carrying capacity for deer of foothill ranges in the Intermountain West is declining and has been for several decades (Salwasser 1976; Urness 1976, 1979, 1982; Longhurst et al. 1983). This is the result in many cases of (1) senescence and death, without replacement, of aging shrub stands, (2) much reduced or eliminated livestock grazing leading to secondary succession back to grass-forb dominance at lower elevations, and (3) thickening of shrub and tree species of lesser value at somewhat higher elevations. The purpose of this review is to summarize the results of research over the past 30 years that offer solutions to the problem of declining deer carrying capacity.

The Sagebrush-Grass Zone

Natural Communities

Smith (1949) was the first to formally document declining shrub stands on foothill ranges where livestock were removed and deer use was heavy. This occurred over a remarkably short time (11 years) suggesting that competitive relations between shrub and herbaceous species can shift rapidly under single use. Remeasurements of the area in 1982 indicated the downward trend in shrub density and vigor on the "deer range" continued to extinction and that the former "livestock range" (subsequently removed from livestock use about 1957) had the appearance of the deer range in 1948 (table 1).

The upshot of Smith's 1948 data and later observations along the Wasatch Front throughout the 1950's suggested the need to research the question of whether carefully managed livestock grazing in terms of intensity and timing could reverse the decline in shrub vigor. Preliminary clipping studies showed that removal of understory forage around individual bitterbrush plants increased current annual growth of twigs by 50% (Smith and Doell 1968). A series of followup studies at Hardware Ranch east of Logan showed that cattle, sheep and horse use could achieve a similar result (Smith and Doell 1968, Jensen et al. 1972, Reiner and Urness 1982); however, none of these were sufficiently long-term to assess whether shrub densities would increase, so we are left with the presumption that the process (overgrazing) that created shrub dominance from grassland could do so again. It is highly unlikely that the magnitude of livestock pressure imposed a century ago will be tol-

Table 1.—Changes in density of important plant species on foothill range with removal of livestock for various periods and continuous winter use by mule deer (total plants on 70,100 square foot plots).

		1948[1]		1982[2]	
		Deer	Livestock	Deer	Livestock
Forbs					
	BASA[3]	676	96	1696	704
	HEUN	243	3	140	75
	WYAM	64	8	5	6
Grasses					
	ELSP[4]	24	9	136	3984
	POSA	1610	667	2040	1750
Shrubs					
	ARTR (Dead)	185	92	0	122
	ARTR (Live)	88	580	0	98
	CHNA	2	23	0	0
	GUSA	29	185	1	128

[1]*In 1948 the deer range received heavy winter use by deer only (livestock were removed in 1937); the livestock range received heavy use by cattle in summer and light use by deer in winter (Smith 1949).*

[2]*In 1982 both units received heavy use by deer only during snow-free periods in winter; the livestock were removed from that unit in 1957.*

[3]*Plant names are listed in appendix.*

[4]*This grass occurred as rhizomatous patches on some plots.*

erated again. Therefore, it seems prudent to not allow secondary succession to go that far and to take action to assure maintenance of the desirable mixed shrub-grass-forb communities we yet have.

Studies at Hardware Ranch were on just such mixed communities with *Purshia, Artemisia*, and *Amelanchier* the main shrub genera associated with five important perennial grasses in the genera: *Elytrigia, Koeleria, Leymus, Pascopyrum*, and *Poa*, and four prominent perennial forb genera: *Balsamorhiza, Aster, Geranium*, and *Wyethia*. The three forage classes contributed roughly equal amounts of forage.

Initial tests were of stocking intensity (moderate or heavy) in early, mid- and late-summer grazing periods. Assessment of success was judged on the basis of significant removal of herbaceous species competing with the palatable key shrub *Purshia*, without significant removal of browse needed by deer (table 2). Differences in study design make precise compari-

Table 2.—Mean utilization percentages on important herbaceous forages and shrubs on northern Utah deer winter ranges by season, stocking intensity, and class of livestock.

	Cattle (Smith & Doell 1968)		Sheep (Jensen et al. 1972)		Horses (Reiner & Urness 1982)	
	Moderate	Heavy[1]	Moderate	Heavy	Moderate	Heavy
Early[2] per. gra.	31	41	16	28	45	74
Per. forbs	28	32	21	45	8	18
Purshia	5	13	23	39	0	0
Other shrubs	—	—	10	33	<1	<1
Mid. per. gra.	22	32	17	31	42	75
Per. forbs	12	17	36	43	7	20
Purshia	29	36	69	84	0	0
Other shrubs	—	—	27	46	<1	3
Late per. gra.	22	35	27	39	41	79
Per. forbs	8	10	26	45	8	18
Purshia	31	41	40	63	0	0
Other shrubs	—	—	18	32	<1	3

[1]*Stocking rates differed somewhat between the three studies.*

[2]*Grazing periods also differed but* ***early*** *generally=late May to late June,* ***mid****=late June to early July, and* ***late****=late July to mid August (the sheep study extended into fall).*

sons impossible but the following points appear valid: (1) cattle used grasses more effectively than forbs; the converse was true for sheep, (2) cattle and sheep used the key browse excessively in mid and late periods; sheep were borderline even in the early period, (3) horses used grasses effectively at all times but forbs only lightly, (4) horses essentially never used *Purshia* or other shrubs, (5) all three animals were most effective at reducing herbaceous competition on shrubs at the heavy stocking level and in the early period due to later compensatory growth of shrubs presumably because of soil moisture sparing (Smith et al. 1979). The general conclusion is that all three herbivores would, under controlled early-summer grazing, effectively shift competitive advantage toward shrubs, but horses stand out as the superior manipulator in this situation. Unfortunately, they are less available in large numbers than cattle or sheep. Also it appears that some alternation in use or combined grazing of sheep and cattle would be most successful.

Following the earlier work reported by Jensen et al. (1972), effects of summer grazing by sheep on subsequent winter foraging behavior and nutrition of deer were studied (Smith et al. 1979, Fulgham et al. 1982). Conclusions were that sheep greatly reduced the total herbaceous forage available, but the fall growth of grasses was more accessible to deer and their winter diets were higher in herbaceous components and lower in browse despite increased production of *Purshia* current-growth twigs. Although diet composition was different, nutritive value was not adversely affected and, indeed, a slight improvement in deer dietary crude protein, digestible energy and dry-matter digestibility was noted in the sheep-deer pasture compared to the deer-only pasture in late winter. This is a critical time in a deer's annual cycle. A somewhat earlier greenup occurred in the sheep-deer unit, presumably due to more rapid soil warming where the insulating layer of standing dead material had been greatly reduced by sheep the previous summer.

The common thread in these investigations in northern Utah and those on similar habitats elsewhere in the Intermountain Region (U.S. Forest Service 1970, Salwasser 1976, Leckenby et al. 1982, Neal 1982) is that removal of livestock use in summer to increase browse availability for deer in winter has not been effective. On the contrary, successional shifts adverse to deer carrying capacity have occurred. Management

of succession is an important aspect of the deer habitat biologist's job (Leopold 1950, Urness 1976, Longhurst et al. 1982). It is not enough to passively accept the inadvertent beneficial changes occasionally imposed by livestock in the past (Severson and Medina 1983, p. 26). An active program of driving succession in desirable directions is needed since exclusive use by one animal usually leads in time to unidirectional changes adverse to that animal. Considerable lands have been purchased by the states for deer winter range (Connolly and Wallmo 1981, p. 541) and far more are controlled by federal agencies. These habitats have generally not received adequate management for deer objectives because funding has seldom been available.

Despite challenges to broad application of the Clementsian paradigm of plant community succession in recent years (Walker 1988, Westoby et al. 1989), it appears to work well in the sagebrush-grass zone for interpreting vegetational dynamics with livestock grazing and fire in my area (Blaisdell 1953, Ellison 1960, Laycock 1967, and many others). A general consensus of dynamic shifts from grass-forb dominance to shrubs with heavy spring livestock grazing and a reversal with fire indicates managers have the means to directing succession on deer winter ranges if there is the will to do so. An almost insurmountable obstacle, however, is the prevailing negative connotation of "overgrazing" (Severson and Medina 1983, p. 24). In my view, overgrazing is bad only if it leads succession away from the management objective or it degrades site integrity. In the case of deer winter range management, overgrazing of competitive perennial grasses and forbs may be desirable and necessary to attain or maintain a good mixed community that includes a vigorous shrub component. This overcoming of our negative biases on "overgrazing" parallels the difficulty range managers have had in overcoming the unfortunate value terms, e.g. excellent, good, fair, poor, associated with concepts of range condition and trend related to the ecological "climax" as independent of management goal (Smith 1979, 1989; p.144).

Once controlled application of overgrazing is acceptable and does its job of directing succession such that relative competitive advantage among forage classes has roughly reached an equilibrium compatible with management objectives, the problem then shifts to maintenance utilization levels. As

Smith (1949) has shown, consistently heavy use of shrubs in winter by deer can defeat the goal of shrub parity with herbs. Controlling deer numbers through hunting and even thinking in terms of periodic heavy deer removals to simulate a rotational grazing system incorporating rest (DeByle 1979) is perhaps in order (Welch 1989). Aldo Leopold is quoted by Meine (1988) as writing " . . . managers must become generous in building up carrying capacity . . . stingy in building up stocks." Biologists and hunters as well as the general non-consuming public in Utah have come to view consistently high deer densities as the standard of management. In my opinion, this issue needs reexamination and change. Neither prescription grazing nor deer population control will suffice alone; they must be seen as a package which may, under specific circumstances, also involve tree cutting and prescribed burning or fire suppression (Salwasser 1976).

Seeded Communities

The sagebrush-grass zone has had large areas of foothill and valley floor rangeland, "degraded" by past grazing practice or swept by widespread wildfires, seeded to mostly exotic crested wheatgrasses, *Agropyron desertorum* and *A. cristatum* (Urness 1986). Many deer biologists have deplored the monotypic aspect of most such stands on the basis of frequently large size and loss of shrub forage and tree cover (Vale 1974, Terrel and Spillett 1975, Wagner 1978, Severson and Medina 1983). Less attention has been paid to the nutritional contributions seeded sagebrush-grass sites provide deer (Leckenby 1969, Heady and Bartolome 1977, Willms and McLean 1978, Austin and Urness 1983, Heady 1988). No consensus on this controversial issue can be expected, but the seedings are extant and the question remains: How do we manage them for deer?

New growth leaves of native and seeded grasses are high quality forages for deer in spring and fall (Koehler and Leckenby 1970, Urness et al. 1983). At times they dominate deer diets when snow cover is partial or absent. In some situations, deer access to this low-growing forage is impeded by standing dead biomass (Willms et al. 1979, Willms et al. 1980) and heavy livestock use and fire are means to increase access. Austin et al. (1983) agree with this in Utah with the caveat that under certain snow-cover conditions the fall-growth leaves of

grasses can be made available to deer by differential melting of snow around the bases of tall standing bunchgrasses via a blackbody effect. Thus some portion of grassland and seedings should remain ungrazed the previous fall within a deer's winter home range to provide maximal access before snowmelt is complete. Since snow depths over about 30 cm preclude deer access to green grass forage, a patchy interspersion of shrublands and grazed and ungrazed grass seedings are the goal. Mixed seedings with all three forage classes are a superior ideal but successes are often limited (Leckenby and Toweill 1983).

Gambel Oak Communities

Gambel oak in shrub and tree form dominates large areas at intermediate elevations generally above sagebrush-grass and below aspen-mixed conifer types in the Utah-Colorado-New Mexico-Arizona region. In northern Utah it most commonly interfaces with deer winter range on the upper foothills and interior valleys along the Wasatch Front (Austin et al. 1986). In some cases it is in almost monotypic clones and in others it is a more open complex associated with 6-8 shrub species. The somewhat higher elevation, greater snow accumulations, and deciduous nature, e.g., low nutritional value of winter twigs (Kufeld et al. 1981, Welch et al. 1983) of oakbrush types have led some to depreciate its value as deer winter range. Perhaps that is justified in stands that have advanced successionally to overwhelming dominance by oak. However, three elements indicate the need for reevaluation: (1) human pressures on low-elevation sagebrush-grass types reducing their value to deer, e.g. recreational uses, developments, and successional loss of shrubs, (2) opportunities to manage through grazing for a better mix of shrubs in the oak type, and (3) cold temperature inversions at lower elevations that are a greater energetic drain on deer there contrasted to warmer intermediate-elevation oak types during very cold winters like 1988-89.

All three of these issues are important, but I will confine my remarks to the second one; namely, how oakbrush communities can be made more useful as deer winter range via grazing manipulations. Gambel oak cannot be managed effectively by prescribed fire, herbicides, or mechanical means (Kufeld 1983) because its response as a strong root-sprouter is usually more

robust than most shrub associates. A selective control specific to oak is needed and that appears to be heavy prescription browsing in summer with Spanish goats (Riggs et al. 1988, Riggs and Urness 1989, Riggs et al. 1990).

A mixed shrub community dominated by Gambel oak clones up to 2 m in height was studied in the Weber River Valley near Henefer. Besides oak, the important shrubs were big sagebrush, snowberry, serviceberry, Douglas rabbitbrush, and bitterbrush. Normal succession on this semi-arid site is a progressive thickening of oak clones and declining densities and production on other shrubs more important to wintering deer, especially big sagebrush (Austin et al. 1986). A 2-year series of heavy defoliations of oakbrush occurred in 1984 and 1985 when it was determined that Spanish goats preferred it to most other shrubs except serviceberry (not abundant in the community). Following cessation of goat browsing, measurements in 1986 revealed that only oakbrush and serviceberry exhibited reduced productivity compared to control pastures and big sagebrush increased. Most of the live oak stems remaining were sprouts. Remeasurements in 1989, four growing seasons after goat browsing ceased, have yet to be analyzed but oak was observably less abundant than in 1986 indicating a longer than expected suppression. This is encouraging because it suggests heavy periodic browsing rather than every-year use will maintain the desirable open stand with ample oak sprouts and vigorous associated shrubs.

Reduction of deciduous browse by goats resulted in increased use of Wyoming big sagebrush by deer in winter compared to control pastures when snow precluded use of understory species. Resulting deer diets in goat-browsed pastures contained less fiber and tannins and were more digestible than those in control pastures. When snow cover was absent, deer shifted to grazing herbaceous forages, not significantly altered by goat use, and nutritional differences disappeared. Goat-induced vegetal differences did not affect deer activity budgets or foraging behavior (biting rates or intake rates).

It is concluded that Spanish goats can effectively manipulate oakbrush communities to: (1) increase production and use of a nutritionally superior browse (sagebrush) by deer and, more importantly, (2) interrupt the successional trajectory that leads to increased oak at the expense of other shrub associates. This knowledge is presently limited in application by the scarcity of

goats in the Intermountain Region, so must be viewed as a developing technique. Resistance to use of goats here, no less than other regions, will impede progress unless attitudes in land management agencies shift. It is more likely that acceptance will come from the private sector.

Parting Shots

Connolly and Wallmo (1981) stated and Severson and Medina (1983) agreed that benefits of livestock grazing to deer and other wildlife have been essentially fortuitous. What I am suggesting here is that it is time to remove the element of chance and make planned grazing prescriptions. The concepts expressed here regarding use of livestock to manipulate deer range composition and structure are not new. The fact that few operational programs are extant obviously must reflect not the lack of awareness but, rather, a failure of will to allocate resources. Infrastructure necessary for controlled grazing (fencing) has collapsed or disappeared on many foothill areas along the Wasatch front as grazing was phased out over the past half century and these areas were devoted to watersheds as their highest use. Replacement of fences would be expensive and this is unlikely even if funds become available, in my opinion. Consequently, I predict a gradual decline in carrying capacity for deer on northern Utah Foothill ranges that proceeds at a more rapid rate than preemption of these lands for development and other uses. Recent shifts in managerial attention from deer to elk may cancel concerns for the traditional animal. In effect, we are seeing situation management that merely acquiesces to the changes outlined by adopting another animal more suited to these changes. This does not in itself bother me, so long as the sportsmen and general public, accustomed to viewing deer as the premier species, understand the successional process and agree that this is acceptable.

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Appendix A.—Plants mentioned in the text

Scientific name	Symbol	Common Name
Shrubs[1]		
Amelanchier alnifolia	AMAL	serviceberry
Artemisia tridentata	ARTR	big sagebrush
Chrysothammus nauseosus	CHNA	rubber rabbitbrush
C. viscidiflorus	CHVI	Douglas rabbitbrush
Quercus gambelii	QUGA	Gambel oak
Symphoricarpos oreophilus	SYOR	snowberry
Gutierrezia sarothrae	GUSA	broom snakeweed

Scientific name	Symbol	Common Name
Forbs		
Aster chilensis	ASCH	Pacific aster
Balsamorhiza sagittata	BASA	arrowleaf balsamroot
Geranium fremontii	GEFR	Fremont geranium
Helianthella uniflora	HEUN	oneflower helianthella
Wyethia amplexicaulis	WYAM	mulesear wyethia
Grasses		
Agroypyron cristatum	AGCR	crested wheatgrass
A. desertorum	AGDE	crested wheatgrass
Elytrigia spicata[2]	ELSP	bluebunch wheatgrass
Koeleria cristata	KOCR	junegrass
Leymus cinereus[2]	LECI	basin wildrye
Pascopyrum smithii[2]	PASM	western wheatgrass
Poa pratensis	POPR	Kentucky bluegrass
Poa secunda	POSE	Sandberg bluegrass

[1]*Names follow: Beetle, A.A. 1970. Recommended plant names. University of Wyoming, Agricultural Experiment Station Research Journal 31. 124 p.*

[2]*Names follow in part: Dewey, D.A. 1983. Historical and current taxonomic perspectives of* Agropyron, Elymus, *and relatedgenera. Crop Science 23:637-642.*

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Using Short Duration Grazing to Accomplish Wildlife Habitat Objectives[1]

Fred S. Guthery,[2] Charles A. DeYoung,[3] Fred C. Bryant,[4] and D. Lynn Drawe[5]

Abstract.—We review short duration grazing (SDG) by cattle as a tool for managing wildlife habitat. The most consistent habitat effect of SDG has been a reduction in aboveground herbaceous phytomass. This effect could be used in management of wildlife species inhibited by ground cover that is too tall and dense. Wildlife responds to herd rotation through a grazing cell, but deleterious effects on populations are undocumented. The SDG concept provides many options in managing wildlife habitat.

Introduction

Single-herd, multipasture, rapid-rotation grazing has been topical in range and wildlife management since the 1970s. Herein, we call this approach short duration grazing (SDG). We consider the terms cell grazing, Savory grazing, high performance grazing, and time-controlled grazing as largely synonymous with SDG in concept, if not necessarily in application.

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[2]*Fred S. Guthery is Research Scientist, Caesar Kleberg Wildlife Research Institute, Texas A&I University, Kingsville, TX 78363.*

[3]*Charles A. DeYoung is Professor of Wildlife Management, Texas A&I University, Kingsville, TX 78363.*

[4]*Fred C. Bryant is Professor of Range and Wildlife Management, Texas Tech University, Lubbock, TX 79409.*

[5]*D. Lynn Drawe is Assistant Director, Rob and Bessie Welder Wildlife Foundation Refuge, Sinton, TX 78387.*

Under SDG, a single herd of livestock rotates rapidly through several relatively small pastures. Grazing periods typically last 1-5 days with rest periods of 30-60 days (Savory and Parsons 1980), depending on the number of pastures in the system and the rate of plant growth. The grazing cell, with fencelines radiating from a central watering facility (Savory and Parsons 1980), is a common design for SDG.

SDG as popularized has several unique principles or features which raised questions about the impacts of this system on wildlife. The first concern was stocking rates. Savory (1983:157) averred that "no matter how bad the range deterioration there is never a need to reduce stock numbers to start the reclamation process [under SDG]. As a general rule, the conventional or government-prescribed stocking rates can safely be doubled in the first year of operation...." Because increased numbers of livestock were put in smaller pastures, short-term, within-pasture stock densities could be 16-90 times greater than under continuous grazing (CG) (Savory and Parsons 1980). Wildlife managers and researchers were wary of potential impacts. For example, effects of this intense stocking on ground nests, subject to trampling, were unknown. Further, double stocking and herd concentration seemed likely to affect the structure and composition of ground cover. Another concern was the behavioral response of wildlife to herd rotation. Would home ranges and movement patterns be disrupted? Lastly, SDG uses a single water source to facilitate herd movement among pastures. Would this water be available to wildlife species requiring free water?

Our purpose is to discuss SDG as a wildlife habitat management tool. We treat (1) the hypothesized and measured effects of SDG on the physical and biotic environment, because wildlife managers must have this information for sound decisions, (2) behavioral responses of wildlife to SDG's unique features, and (3) population responses of wildlife to SDG. We conclude with suggestions for using SDG to manage wildlife habitat.

Before proceeding, we note that the research literature includes a diversity of experimental designs in measuring the effects of SDG. Further, some studies simultaneously compared several grazing systems. We stress comparisons between SDG and CG, because most of the wildlife research has compared the effects of these two approaches. In the comparisons we report, stocking rates under SDG were higher than those under

CG unless otherwise indicated. However, maintenance of doubled stocking rates rarely has been possible in operational, field-scale studies.

Hypothesized and Measured Effects of SDG

Distribution of Grazing Pressure

Increased stocking rates and smaller pastures associated with SDG have been hypothesized to result in a more uniform distribution of grazing pressure (Savory and Parsons 1980, Heitschmidt and Walker 1983). (Improved distribution could provide at least a partial explanation of why stocking rates might be increased.) More uniform grazing could degrade habitat quality for those wildlife species that benefit from patchy ground cover, such as northern bobwhites *(Colinus virginianus)* (Guthery 1986) and scaled quail *(Callipepla squamata)* (Ault 1981). Furthermore, uniform grazing could result in homogeneous structure and composition of vegetation, which would reduce wildlife diversity.

The uniform grazing hypothesis generally has failed to hold in field-scale studies. In southern Texas, cattle use of vegetation types was more uniform under SDG than under CG (DeYoung et al. 1988). However, cattle showed stronger selection for soil series and distance from water under SDG than under CG. Likewise, in northern Mexico, the distribution of herbaceous phytomass indicated heavier grazing nearer to water and lighter grazing further away (Soltero et al. 1989). This resulted in a "bull's-eye effect," i.e., concentric zones of vegetation depletion toward the central water facility.

Observations suggest the same effect occurred in DeYoung et al.'s (1988) study area. Livestock preference for plant communities was not affected by either 14- or 42-pasture cells in the Rolling Plains of Texas in comparison with CG (Walker et al. 1989). Cattle were actually less selective for plant communities as livestock density decreased, contrary to expectations. Walker et al. (1989) attributed this result to low stock numbers relative to forage availability, which made selectivity by livestock unnecessary.

Water Infiltration and Seedling Establishment

"Hoof action" from increased stocking rates and smaller pastures was hypothesized to improve water penetration by breaking up organic and inorganic crusts on the soil surface (Savory and Parsons 1980). Likewise, hoof action was thought to improve establishment of grass seedlings.

In comparison with areas excluded from grazing or under moderate continuous grazing (MCG), research results indicate SDG *decreases* infiltration and reduces soil moisture. These results were observed in Canada (Dormaar et al. 1989), New Mexico (Weltz and Wood 1986), the Rolling Plains of northern Texas (Pluhar et al. 1987), and the Edwards Plateau of central Texas (Thurow et al. 1988). Thurow et al. also demonstrated that SDG pastures suffered increased interrill erosion and took longer to recover from drought than did MCG pastures. Pastures under heavy continuous grazing (HCG) had inferior hydrologic variables, similar to those under SDG. In the Edwards Plateau, stocking rate rather than grazing management was the key influence on infiltration and erosion.

Likewise, there is a lack of convincing data that SDG generally improves seedling establishment. Bryant et al. (1989) summarized tests of the seedling establishment hypothesis conducted in the Coastal Prairie and Rolling Plains of Texas. In the Coastal Prairie, hoof action seemed to favor establishment of Medio bluestem *(Dicanthium aristatum)*, a weedy grass, but had no effect on establishment of Rhodesgrass *(Chloris gayana)*, buffelograss *(Cenchrus ciliaris)*, and arrowleaf clover *(Trifolium vesiculosum)*. In the Rolling Plains, SDG provided no beneficial effect on seedling establishment.

Reversed Desertification

Savory (1983) reported that short duration grazing can reverse desertification. This reversal presumably would be associated with improved range condition (higher successional status of vegetation). If SDG could advance succession, it would be a powerful wildlife management tool. Habitat management largely involves creation of the proper successional stage for the target species.

Research suggests that actual effects of SDG are contrary to Savory's (1983) hypothesis. We previously discussed how

higher stocking rates associated with SDG have resulted in decreased infiltration and increased erosion. These outcomes exacerbate desertification. Further, studies ⩾4 years in duration have revealed neutral impacts of SDG on successional trends (Pitts and Bryant 1987) or a decline in range condition (Soltero 1987, Thurow et al. 1988, Bryant et al. 1989, Dormaar et al. 1989).

Standing Crop Phytomass

If SDG reversed desertification and elevated the successional status of rangeland plant communities, a corollary outcome would be increased standing crop phytomass. Results of two studies support this hypothesis. In the western Rio Grande Plains of Texas, more ground cover was reported to be available under SDG than under CG during drought (Campbell-Kissock et al. 1984). In the Edwards Plateau, standing crop phytomass was higher under SDG than under HCG at similar stocking rates (Thurow et al. 1988).

Elsewhere, SDG generally reduced standing crop phytomass in comparison with CG. These results were based on both indirect (Bareiss 1985, Wilkins 1987, Schulz and Guthery 1988, Swanson 1988) and direct (Heitschmidt et al. 1987, Pitts and Bryant 1987, Soltero 1987, Thurow et al. 1988) measurements of phytomass. Presumably, the tendency toward decreased herbaceous phytomass results from increased stocking rates. Increased trail-forming (Walker and Heitschmidt 1986) and trampling of vegetation as a result of herd density could also be involved.

The response of specific components of standing crop phytomass is also of interest to wildlife managers. If SDG caused a shift in phytomass toward grasses and away from forbs, the implications for wildlife management would be numerous. For example, SDG could be used to create nesting cover for those ground-nesters that use grasses if lack of nesting cover limited a given species. In semiarid regions, SDG caused a shift in phytomass toward forbs, not grasses (Pitts and Bryant 1987, Bryant et al. 1989). Wilkins (1987) also noted decreased height and coverage of grasses under SDG. In a subhumid environment, Cohen et al. (1989a) reported forbs preferred by white-tailed deer *(Odocoileus virginianus)* were more abundant under CG rather than under SDG. These findings,

though inconclusive, may affect decisions for managers using SDG to promote forage or cover species for wildlife.

Wildlife Response to SDG'S Unique Features

Altered Water Availability

The role of watering facilities in herd management differs between SDG and CG. Under CG, water facilities function to distribute grazing pressure throughout a pasture. Grazing pressure is optimally distributed, in a forage management sense, when the availability and distribution of watering facilities complement the distance livestock readily travel to and from water. Thus, larger pastures may contain several watering facilities.

In SDG, conversely, one watering facility is the focus of herd management. This facility attracts the herd to a single location, whence it can be shunted to the next pasture in the rotation. Peripheral water facilities must be fenced or deactivated under SDG.

Wildlife use of livestock water under SDG and CG has been determined in southern Texas (Prasad and Guthery 1986). Brown-headed cowbirds *(Molothrus ater)* exhibited much heavier use of water at SDG cell centers than at facilities in CG pastures. Mourning dove *(Zenaida macroura)* use of water was unaffected by grazing treatment. Wild turkeys *(Meleagris gallopavo),* collared peccaries *(Tayassu tajacu),* and white-tailed deer were not observed using water at cell centers, whereas they readily used water in CG pastures.

The concentration of human traffic and livestock at cell centers likely limited water use by some wildlife species. Human traffic was at least twice as high at cell centers as at watering facilities in CG pastures, caused in large part by major ranch roads that intersected the cell centers. Students, petroleum workers, and ranch personnel used these roads. Concentrations of cattle were also higher at cell centers than at water facilities in CG pastures, as would be expected if a given number of livestock had access to one versus several facilities.

Prasad and Guthery (1986) concluded that, where possible, peripheral water facilities should be preserved under SDG to

benefit wildlife species requiring free water. They recommended fencing of peripheral facilities to facilitate herd rotation.

Livestock Concentrations

Bryant et al. (1982) first addressed the concern that SDG might foster high trampling rates of ground nests because of doubled stocking rates and intensive, short-term concentration of livestock in smaller pastures. They presented evidence that smaller SDG pastures would reduce movement of livestock in comparison with larger pastures, thereby decreasing the probability of nest trampling. Further, at any time a large percentage (>85%) of the area in an SDG program is likely to be devoid of livestock, whereas 100% of a CG pasture is susceptible to grazing. Bryant et al. concluded that the relative danger of trampling loss is fairly constant, regardless of the grazing program.

Field research has supported the analysis of Bryant et al. (1982). Trampling of simulated nests (clay targets) was statistically similar between SDG and CG treatments in the High Plains of Texas (Koerth et al. 1983). In the Coastal Prairie and Rio Grande Plains of Texas, coverage, density, and dispersion of suitable nest sites and trampling loss rates of artificial bobwhite and turkey nests were similar between SDG and CG (Bareiss et al. 1986). These results occurred despite higher livestock densities in the SDG treatments than in the CG treatments on two of three study areas.

Herd Rotation

White-tailed deer commonly avoid cattle-stocked pastures under SDG (Hyde 1987, Cohen et al. 1989a). Cohen et al. found a statistically significant relationship between locations of radio-equipped deer and herd rotation for two of eight cycles of cattle moving through an SDG cell. In both cases, deer avoided cattle. Also using radio-telemetry, Hyde (1987) found that deer would move to adjoining pastures when cattle were present in a pasture containing the deer's activity center. Generally, deer use of the pasture returned to "normal" 7-21 days after the cattle left.

Deer apparently react initially to the physical presence of a high density cattle herd, as opposed to some ecological change

induced by cattle (Adams 1978). Deer may vacate a pasture newly stocked with cattle within a few hours of stocking. Hyde (1987) analyzed deer use of plant communities, soil types, and distance zones from water when cattle were present versus absent from the SDG pasture containing the deer's activity center. Although some differences were detected, Hyde concluded that cattle were not causing deer to use less preferred habitat.

Home range sizes of deer were similar on SDG and nearby continuously grazed pastures (Hyde 1987, Kohl et al. 1987, Cohen et al. 1989a). Thus, in avoiding cattle during herd rotation, deer appeared to rearrange their internal home range movements rather than ranging over a larger area. Furthermore, Hyde (1987) found deer radio-tracked up to 3 years exhibited no tendency to leave an SDG cell. During part of his study, this cell was stocked with cattle at a rate 62% greater than adjacent continuously grazed range.

Limited data suggest herd rotation in SDG has no adverse effects on turkeys in environments with deep soils, long growing seasons, and about 63 cm at annual precipitation. On an 8-pasture, 1,142-ha cell in Brooks County, Texas, radio-equipped wild turkeys moved to adjacent pastures 80% of the time when the herd entered a particular pasture (Schulz and Guthery 1987). Most (65%) of these birds returned to the pasture with cattle in ≤4 days. Turkey use of pastures, based on radio locations, appeared to be most intense in the more recently grazed pastures. However, pasture status relative to herd rotation had no significant effects on turkey use patterns, and home range sizes were statistically similar between a CG and an SDG treatment.

The response of bobwhites to herd rotation has been variable. Bareiss (1985) found no significant effects of herd rotation on bobwhite density within pastures. This finding suggests bobwhites did not move among pastures in response to presence of the herd. Schulz and Guthery (1988), however, observed lower mean densities in the pasture with cattle present than in the one rested for the longest period, indicating quail may have moved to the next pasture in the rotation. Conversely, Sloan (1987), working at the same study area as Bareiss (1985), found a significant inverse relationship between the length of time since a pasture was last grazed and the number of radio locations within pastures in 1 of 2 years of study. In other words, bobwhite use as indexed by radio locations

tended to be highest in the most recently grazed pastures. Sloan attributed the disparate findings to differences in annual rainfall. Bareiss worked during one of the wettest years on record, when vegetation structure remained dense, i.e., poor for quail, despite the presence or absence of cattle or the length of time since a pasture had been grazed. Sloan worked during a drier year when presence of the herd apparently improved the structure of ground cover for quail.

Wildlife Population Responses to SDG

Nongame Wildlife

With the exception of Nagendran (1987) and Swanson (1988), research on the effects of SDG on nongame wildlife is lacking. Both studies took place on ranch-scale study areas where inherent variability and prior treatment effects could have influenced results. Much additional work is needed before definitive conclusions can be drawn.

Nagendran (1987) studied the effects of CG and SDG on eastern cottontail rabbits *(Sylvilagus floridanus)* and rodents at two locations in south Texas. At a Coastal Prairie site she found that SDG did not negatively affect either range condition or rodent and cottontail populations. However, mammal numbers were low on both treatments and her conclusions may not be repeatable at higher population levels. On a second location in the drier Rio Grande Plain, Nagendran (1987) reported significantly more rodents on an SDG than on a CG treatment. Her trapping sites on the SDG pasture were more heavily vegetated than those on the CG pasture, and the greater abundance of rodents was attributed to the amount of herbaceous cover.

Swanson (1988) studied the effects of four grazing treatments (HCG, MCG, heavy deferred-rotation [HDR], and heavy short duration [HSDG]) installed in late 1982 on vegetation characteristics and abundance, distribution, and community composition of grassland birds in the Coastal Prairie of south Texas. In 1983 he found vegetation under HSDG had the lowest effective height, lowest maximum height, and lowest litter depth among treatments, although the differences were not

significant. In 1983 bird communities showed the greatest species richness and diversity in the HDR treatment, although not significantly different from the HSDG or HCG treatments. The MCG treatment had significantly lower bird species richness, diversity, and density than the other 3 treatments. The number of plant species declined significantly in all but the HSDG treatment from 1983 to 1984. Herbaceous canopy cover declined on all treatments between years. Variance in effective vegetation height and maximum height was greatest under HSDG in 1984, showing a treatment effect favoring diversity in fine vertical structure. This is contrary to the even physiognomy predicted by Savory (1979) for SDG. Bird species richness was highest under HSDG in 1984. HSDG was the only system to show an increase in bird species diversity between years. Bird species richness decreased in all systems in 1984, but the decline was least under HSDG. Increased bird richness and diversity on the HSDG treatment were attributed to a combination of plant species composition and higher variance in structural measures. The HSDG treatment showed more stability in both plant and bird community composition than the other three treatments in 2 years with widely different rainfall patterns.

White-tailed Deer

Whereas cattle rotation under SDG displaces deer within their home ranges, there is no *direct* evidence that this or any other SDG effect is deleterious to deer. Deer moved more (Cohen et al. 1989a) and fed longer (Cohen et al. 1989b) during part of the year in an SDG versus CG area in the Texas Coastal Prairie. These authors speculated that this pattern could be harmful to the SDG deer. In November deer counts from a helicopter, Hyde (1987) reported little change in relative abundance between adjacent SDG and CG treatments over 3 years. However, during a drought year (1984), the helicopter count showed no fawns with any of the 65 females sighted in the SDG area. Fawns were sighted at a ratio of 0.27/female for the 164 females observed in the adjacent CG area. During the other 2 years, fawns were sighted at similar ratios in both areas. Hyde et al. (1987) speculated that coyote *(Canis latrans)* predation on fawns may have been higher in the SDG area in

1984 because it contained less hiding cover compared to the CG area. In an associated study during the 1984 drought, there were no differences between deer on the SDG and CG areas in field-dressed weight, kidney fat index, or fawns *in utero* of female deer collected quarterly (T. F. Kohl et al., Texas A&I Univ., Kingsville, unpublished data, 1987).

Northern Bobwhites

Few significant effects of SDG on bobwhite population density have been observed, but authors have uniformly reported that SDG favored these quail in comparison with CG (Campbell-Kissock et al. 1984, Bareiss 1985, Schulz and Guthery 1988) or two-pasture, deferred-rotation grazing (2PDR) (Wilkins 1987). These authors attributed bobwhite response to improved structure of ground cover in comparison with other grazing programs tested. During drought in the western Rio Grande Plains, more ground cover was available on SDG than on CG treatments (Campbell-Kissock et al. 1984). Conversely, during less severe drought or rainy periods in the eastern Rio Grande Plains and Coastal Prairie of Texas, less ground cover was available in comparison with CG or 2PDR. This effect occurred even if SDG and CG pastures were stocked at the same rate (Bareiss 1985). Wilkins (1987) noted that the disturbances caused by heavy, short-term grazing in SDG pastures increased the availability of bare ground and decreased the height and coverage of grasses. Both of these habitat effects favor bobwhites if ground cover is too dense for these quail.

Using SDG for Specific Wildlife Objectives

How could wildlife habitat best be managed with SDG? Addressing this question poses some problems. First, installation of an SDG program solely to manage wildlife habitat seems unlikely because costs probably would outstrip benefits. Second, there are insufficient data on habitat responses to SDG, although some commonalities (discussed below) appear among study results. Third, use of SDG in managing habitat will vary with the target species of wildlife. With these qualifications understood, managers may benefit from some speculation on managing habitat with SDG.

Structure of herbaceous vegetation is a key factor in wildlife habitat management, and SDG has predictable impacts on this habitat feature. In operational, field-scale studies SDG usually has lowered aboveground phytomass, in comparison with CG and some other grazing programs. Thus, SDG could benefit any species limited by ground cover that is too tall and dense. Conversely, it could exacerbate problems for species lacking adequate ground cover. Of course, increased stocking rates, regardless of the approach to grazing, could have similar results.

The composition or successional stage of herbaceous vegetation is also a key habitat feature. Short-term effects of SDG on composition are unclear, but this grazing program seems to have neutral impact on range condition or results in "declining" range condition. Declining range condition, or lower successional status, benefits lower-seral wildlife species and damages upper-seral species. Wildlife managers can use this outcome of SDG as initial conditions of the habitat and the objectives of management dictate.

Where wildlife is a primary objective of management, we know of no other grazing technology that has the potential power of SDG. SDG results in division of a unit of rangeland into smaller pastures than would be used for other grazing systems. This provides opportunities for management innovation. To manipulate succession or diversity, a manager may graze SDG pastures differently. Some may be rested or grazed more than others to create a variety of seral stages in close proximity. The timing and intensity of grazing may be modified to achieve specific habitat objectives. In fact, grazing pressure may be varied over an entire SDG system in a variety of complex ways. Selecting a grazing mix for various pastures and assessing resultant habitat benefits will be largely subjective. Nevertheless, the SDG concept provides many options.

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Forage Quality as Influenced by Prescribed Grazing[1]

E. William Anderson,[2] David L. Franzen,[3] and Jack E. Melland[4]

Abstract.—Forage quality involves nutritional values, palatability, diversity of perennial species in the floristic composition, and quality of forage. Prescribed grazing must specifically: (1) benefit the resources as top priority which improves vigor and species diversity, (2) involve moderate utilization which provides adequate quantity of forage, and (3) allow for regrowth following grazing in selected management units which affects nutritional values and palatability. Of prime importance is the technique for preconditioning grass forage to improve nutritional quality for autumn/winter grazing. It involves moving livestock out of first-grazed units about mid-growing season, early enough to allow regrowth of forage. This results in a grazing-induced delay in plant phenology so that regrowth is cured by heat/drought when at maximum forage value; a higher than normal level of nutrients are fixed in the mature regrowth.

Case history wildlife responses include (1) annual wintering Rocky Mountain elk *(Cervus elaphus nelsoni)* Animal Unit Month (AUM) increases from 770 to 2,300 in 10 years while concurrently increasing cattle AUMs from 340 to 1,000; and (2) annual summering pronghorn *(Antilocapra americana)* AUMs increased from 750 to 1,000 in 8 years while feral horse

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[2]E. William Anderson is a Certified Range Consultant, 1509 Hemlock Street, Lake Oswego, OR 97034.

[3]David L. Franzen is a Range Conservationist, USDI Fish & Wildlife Service, P.O. Box 111, Lakeview, OR 97630

[4]Jack E. Melland is a Regional Wildlife Habitat Biologist, Oregon Dept Fish & Wildlife, 201 20th Street, LaGrande, OR 97850.

use was reduced from 2,200 to 1,700 AUMs. Spring through autumn cattle use was held at about 12,000 AUMs. Benefits to Roosevelt elk *(C. e. roosevelti),* black-tailed deer *(Odocoileus hemionus columbianus),* and sage grouse *(Centrocercus urophasianus)* have also been reported.

Competitiveness and compatibility between livestock and wildlife on range and forest lands have been vigorously debated, argued with emotional conviction, and written about in many articles designed to influence public opinion. Obligatory resource management decisions have been and are being made on both public and private lands as a result.

The many examples of obvious conflict between livestock and wildlife that have occurred over the years provide some factions primary evidence for concluding that livestock grazing is detrimental to wildlife habitat. There are numerous examples, however, where obvious compatibility exits, along with an ecologically healthy resource, under significant numbers of both livestock and wildlife. The evidence is clear that intolerable competition or incompatibility connotes a degree of mismanagement of livestock, the wildlife, or both in respect to the kind and amount of available resources.

Livestock and wildlife can be compatible on the same range provided that management of each is coordinated with the objectives for the area, phenology and physiology of key forage species, and ecological capability of the resources. Furthermore, there are instances where judicious use of livestock grazing is essential for maintaining good wildlife habitat and examples are cited herein. However, it should be emphasized that merely having livestock on the area is not enough. There has to be a specific management program applied that involves at least three key components. These are:

- Diligent effort on the part of the resource managers—agency and/or ranchers—to ensure project success, starting with a carefully formulated plan of action, preferably a coordinated resource management plan, followed by efforts to refine and improve.

- Adherence to moderate utilization of key forage species and mid-season evaluation of utilization zones within grazing units (Anderson 1969, Anderson and Currier 1973).

- Application of basic grazing system principles, adjusted to fit the land and livestock operation so that they benefit (1) the vegetation as top priority, (2) the long-term livestock operation so that incurred costs can be amortized, and (3) watershed, wildlife, fishery, and recreational values so these benefits can be evaluated along with livestock benefits in assessing results derived from the program.

Forage Quality

Forage quality involves such factors as nutritional values, palatability, diversity of palatable perennial species in the floristic composition, and abundance of available forage.

The most commonly recognized objective for using livestock to improve forage quality for wildlife is to prevent formation of "wolf plants" which is the accumulation of excessive standing leached residues. Wildlife then have ready access to succulent forage when it is available.

If a potential for improving diversity of palatable perennial species in the floristic composition exits—and sometimes it does not—livestock grazing prescribed to accomplish this must be specifically designed to benefit the desired ecological status of the resources as top priority, including adherence to a moderate degree of utilization. This kind of grazing management generally will also improve plant vigor and, therefore, increase production and reproduction of key forage species. This, in turn, improves the abundance as well as diversity of forage for both wildlife and livestock.

Nutritional values and palatability are relatively insignificant concerns during the green-forage growing season except in cases where "wolfy" plants discourage or restrict utilization of succulent forage. However, nutritional values and palatability are very important following the green-forage growing season when grazing animals must subsist on mature forage. This is especially true on big-game and/or livestock winter ranges. Therefore, it is the purpose of this paper to explain how livestock grazing has been used successfully to increase nutritional quality and palatability of mature forage in the Pacific Northwest and to cite studies and case histories illustrating the vari-

ety of situations under which beneficial results have been produced.

Background

Figure 1 illustrates the generalized seasonal relationships between the growth curve of an ungrazed forage grass and storage of plant food (Anderson 1952, 1967), percent of nutrients in the herbage, and nutritional value of the herbage which is the product of herbage volume and percent nutrients.

Personal observations of grazing animals over a period of nearly 40 years produced some questions. Why do grazing animals preferentially graze forage on shallow-soil areas and harsh-environment sites? Why do they prefer regrowth forage and regraze the same plants or areas repeatedly? Why do livestock show better physical condition following a dry spring season when forage volume is reduced than during wet spring seasons when forage volume is unusually high? Why, in a rotation of deferred grazing system, is the unit first grazed in the spring relished by livestock in autumn when they are again grazed in this unit?

Such curiosity led to a search of literature in the early 1970's for scientific explanation. Normal sources of range research gave no clues. However, several reports on agronomic research of cereals, including laboratory experiments reported in plant

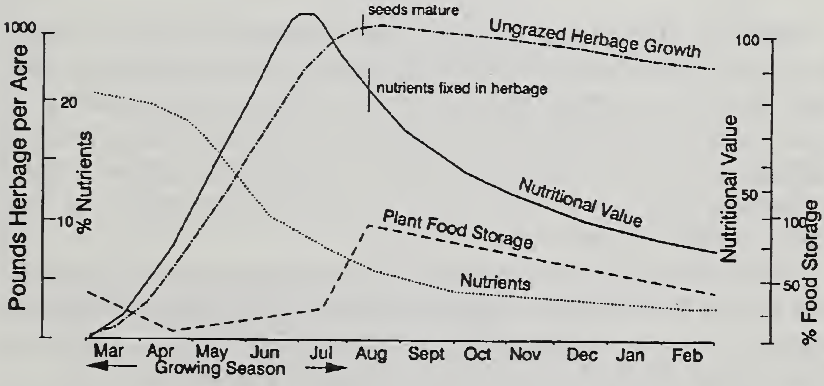

Figure 1. Generalized seasonal relationships between herbage growth of an ungrazed forage grass, plant food storage, percent nutrient content, and nutritional value of herbage (from Anderson and Scherzinger 1975).

physiology textbooks, presented data that seemed to have relevance. Consequently, several suppositions were made based on these agronomic experiments (Anderson and Scherzinger 1975). They are:

- Termination of growth at an immature stage due to heat or drought stops or greatly reduces translocation, thereby fixing nutritional quality of green foliage at a higher level than it would have been had it matured naturally.

- Termination of growth due to heat or drought increases palatability of foliage through conversion of starch to sugars.

- Young-tissue regrowth following grazing may grow a bit longer into the hot dry season thereby increasing volume of nutritious forage.

- Autumn production of green foliage, if and when it occurs, may be more reliable and longer lasting on plants that acquired drought hardiness—therefore frost hardiness—through a reduced water supply while in an immature stage of growth.

Prescribed Grazing

Based on these suppositions, it was apparent that, in order to consciously increase nutritive value and palatability of mature forage for wintering herbivores, the prescribed grazing must delay phenological development of green foliage long enough to make it reach the end of the growing season in an immature stage, at which time the physiological effects of heat and drought would occur.

Manipulating the nutritional curve using livestock grazing as a tool is illustrated in figure 2. Theoretically, the growth and related curves are deliberately interrupted by livestock grazing. Plant physiological functions are thereby postponed or reduced for a sufficient period of time so that, after livestock are removed, leafy nutritious regrowth is "burned" by the advent of hot weather and lack of soil moisture while it is still in an immature stage. A higher-than-normal level of nutrients is

thereby fixed in the mature regrowth, as indicated by the nutritional curve, and starches are converted to sugars in the foliage, by heat and drought. This is the preconditioning treatment that increases nutritional quality and palatability of autumn/winter forage.

The prescribed grazing that has been successful in doing this consists of several principles which should be applied to management units selected for the preconditioning treatment. These are:

- Livestock are moved out of the grazed-first unit about mid-growing season or at least early enough so remaining soil moisture can produce sufficient regrowth before the end of the growing season to provide autumn/winter forage.

- When heat and drought terminate physiological processes, translocation stops. Consequently, this preconditioning treatment may greatly reduce plant food storage in roots the year it is applied because, with preconditioning, forage species do not have enough growing season left to complete their natural physiological cycle, including plant food storage. If the preconditioning treatment were to be repeated on the same management unit several years in suc-

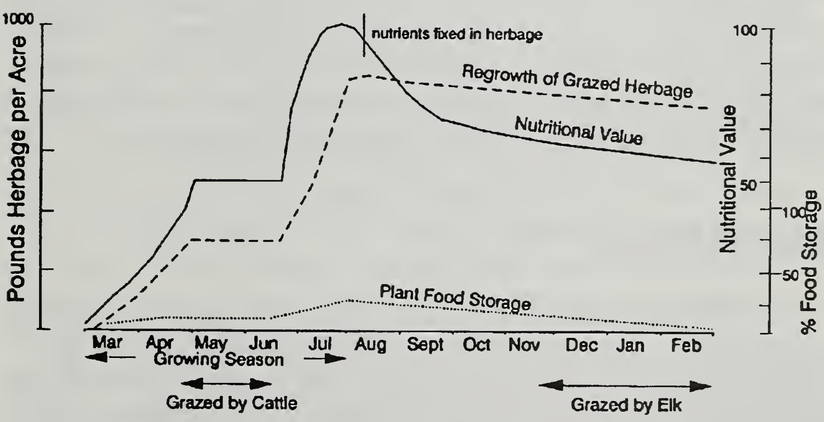

Figure 2. Hypothetical effect of using livestock grazing to interrupt and postpone plant physiological functions so as to improve the nutritional value of mature regrowth forage (from Anderson and Scherzinger 1975).

cession, it could result in reduced vigor of the resource. Therefore, the preconditioning treatment should be rotated among several units over a period of years so it is applied to a particular unit only once every two or three years.

- The rate of livestock grazing in the pretreatment unit should be heavy enough to effectively top-off the unit, yet light enough to leave an adequate volume of green foliage so regrowth can get started without delay after livestock are moved to a different unit. Moderate utilization by livestock should be adhered to each year in all management units within the grazing system so as to leave an adequate volume of forage for wildlife and to provide a volume of weathered forage to help balance animal diets during early spring the following year. Moderate utilization also benefits the resource itself as well as its watershed, fishery and recreational values.

Use of the preconditioning treatment need not be restricted to management units that are primarily low-elevation, early-season grazing. The same principles of removing livestock about mid-growing season to allow regrowth for subsequent late-season grazing also applies to management units that are primarily suited to mid-season and summer-season grazing.

Generally, the more management units that can be "topped-off" with livestock while forage is green, the greater overall benefits will be to both wildlife and livestock. In some terrain and vegetational types, however, the frequency of livestock moves is a limiting factor from a practical standpoint.

Does It Work?

Pitt (1986) conducted a research study to assess the validity of biological assumptions involved in the preconditioning treatment to improve forage quality. He clipped plants of bluebunch wheatgrass *(Agropyron spicatum)* at four phenological stages to compare forage quality of subsequent regrowth relative to nondefoliated plants. He reported that clipping at boot and emergence for two years delayed flowering by 16 and 15 days, respectively, while subsequent flowering of plants

clipped at flowering and seed formation occurred only sporadically. These delays in plant phenology altered forage quality on 26 October compared to nondefoliated plants. Clipping at boot, emergence, flowering and seed formation reduced percent foliar acid detergent fiber, while increasing relative proportions of crude protein, calcium, and phosphorus compared to untreated herbage. Crude protein in plants clipped for two years at emergence, flowering, and seed formation averaged 11.9%, 12.5%, and 13.7%, respectively. Phosphorus in regrowth foliage of plants clipped at flowering and seed formation equalled 0.22% and 0.26%, respectively, on 26 October. These values exceed maintenance requirements of cattle and elk, indicating that judicious grazing management can improve nutritive values of bunchgrass vegetation. These results support the theoretical potential to improve fall forage quality with cattle grazing during spring, which delays plant phenology of subsequent regrowth. This regrowth provides higher forage quality not only because of younger photosynthetic tissue, but also because of increased availability due to the removal of old growth. Moreover, the magnitude of improved forage quality is sufficient to warrant considerable interest for grazing management planning.

Roosevelt elk *(Cervus elaphus roosevelti)* and black-tailed deer *(Odocoileus hemionus columbianus)*.— Rhodes and Sharrow (1983) conducted a study to evaluate the effect of sheep grazing on Roosevelt elk and black tailed deer habitat in Douglas-fir plantations in Oregon's coastal range. They reported that, "In general, sheep grazing reduced October standing crop. However, in the following March, there was generally more standing crop on the grazed areas than in the ungrazed areas and this was especially true of herbaceous species. Most species from grazed areas had higher crude protein values during October than samples from ungrazed areas, both in 1981 and 1982. Browse species which were grazed also tended to have higher levels of crude protein in October than those which were not grazed."

They explained, "Though grazing in the spring and summer tends to reduce total forage biomass present in autumn, it increases forage quality. Winter diets of black-tailed deer in the Coast Range are probably deficient, not in forage quantity, but in forage quality. Forage must be approximately 7 to 10 percent crude protein during the winter in order to meet the nu-

tritional needs of black tailed deer. Many of the ungrazed plots collected in October would barely meet this minimum criterion. However, higher crude protein values observed for plants from grazed areas should assist animals in selecting a diet which more nearly meets their minimal nutritional needs. Similarly, higher *in vitro* dry matter digestibility of grazed plants should help black-tailed deer and Roosevelt elk meet their energy requirements."

"Sheep grazing also appears to enhance big game habitat in the spring. At this time, most of the forage present on the forest is past year's growth and is of low quality. However, new growth which occurs in the spring is of high quality in terms of both digestibility and crude protein. Our data suggest that in March there is more high quality forage in the grazed areas than in the ungrazed areas. This was especially evident in herbaceous vegetation, which is an important component in the diets of black-tailed deer and Roosevelt elk at this time of year."

Sage grouse *(Centrocercus urophasianus)*.—Carol Evans (1985), in her study of sage grouse, compared grazed and ungrazed meadows and found that in mid-July sage grouse were not selective of one over the other. From late July to late August, grazed meadows contained significantly more grouse/ha than ungrazed. She attributed the attraction to midsummer food abundance, mainly common dandelion. By mid-August, however, the phenology of food plants on grazed meadows was the factor that correlated with sage grouse density. Meadows, where phenological development was delayed by livestock grazing and the plants remained green, contained more grouse/ha than meadows where the vegetation had cured. Grazing maintained the forage at a green stage more favorable for the grouse. She also compared two grazed plots with an ungrazed one. The grazing treatments produced succulent leaves favored by foraging grouse whereas the ungrazed one did not. Grazing of meadows, therefore, appears to favor habitat for sage grouse broods because, through grazing, forb quality is enhanced for sage grouse.

Obviously, however, the intensity of grazing is a key factor because it influences the ability of wet meadows to remain wet meadows indefinitely. Prolonged severe utilization damages the vegetational cover which, in turn, accelerates gullying, lowers the water table, and meadow vegetation is replaced.

Moderate utilization benefits meadow vegetation in that it characteristically produces a summer-time patchy mosaic of vegetational heights in which spots are closely clipped while others have standing residues. Participants in various field reviews of grouse habitat have surmised that this patchy utilization might be beneficial to sage grouse because it provides hiding cover from predators, yet the succulent forage they prefer is readily available in the closely grazed patches.

Rocky Mountain elk *(C. e. nelsoni)* and blue grouse *(Dendragapus obscurus)*.—Preconditioning forage by cattle grazing to improve nutritional quality of forage for wildlife has been practiced since 1965 on the Bridge Creek Wildlife Management Area in northeastern Oregon (Anderson and Scherzinger 1975). At that time, cattle were allotted 340 AUMs of forage during spring/early summer, and elk took 770 AUMs of forage during winter. About 12 years later during the period 1976-78, elk averaged 2,530 AUMs and cattle averaged 1,020 AUMs, which is an increase of 230% for elk and 200% for cattle.

In 1981 elk numbers dropped due to a heavy antlerless harvest to reduce the herd. While elk numbers were down it was necessary to increase cattle grazing to maintain succulent forage and prevent formation of overmature wolfy plants which elk reject in favor of succulent grazed plants. In 1987, 22 years after the program started, elk took 1,745 AUMs and cattle 1,225 AUMs of forage, indicating how this project has successfully maintained its objectives.

Mule deer *(O. h. hemiounus)* did not respond as did elk to this prescribed cattle grazing because, on this project, they primarily use steep canyon sites which are virtually ungrazed by cattle. Deer counts followed regional trends in which population lows follow prolonged severe winters.

Results of this prescribed grazing far exceeded expectations in terms of beneficial results on vegetation. For example, in an area rated the most deteriorated and eroded by a 1964 range inventory, Idaho fescue *(Festuca idahoensis)*, which is the dominant species in the potential natural plant community for this site, was rated at 2% of total vegetational cover and the total cover was rated as being only one-tenth that of PNC. In 1988 this same area had recovered to the point where it had 50% total vegetational cover, which is about three-fourths that of PNC. Idaho fescue had increased to 40% of total cover with

young plants being abundant. Estimated usable forage on this particular area has increased from about 75 pounds to 300 pounds per acre (Anderson et al. 1990).

Blue grouse were rarely seen in the grasslands on Bridge Creek before the prescribed grazing program started, yet this is their natural nesting habitat. As the ecological status and vigor of grassland vegetation improve, blue grouse have become a common sight.

Pronghorn *(Antilocapra americana)* and sage grouse.—In 1969 a resource management and development plan was formulated for the Hart Mountain National Antelope Refuge in south central Oregon. That year pronghorn took 565 AUMs of forage during spring-summer-autumn; feral horses took 750 AUMs during yearlong occupancy; and cattle took 12,156 AUMs during spring-summer-autumn grazing. In 1979 the rotation of deferred grazing systems were adjusted to incorporate accumulated improvements and improve the preconditioning treatment of selected management units so that regrowth would follow early grazing, weather permitting.

During the first 10 years of this management plan (1969-79), annual pronghorn use averaged 750 AUMs; during the last 8 years (1979-87) it averaged 1,210 AUMs for an increase of 60%. During the first 10 years, annual feral horse use averaged 2,160 AUMs; the last 8 years it was reduced to an average of 1,735 AUMs by winter round-ups, which is a 25% reduction. During the first 10 years, annual cattle use averaged 12,625 AUMs; during the last 8 years it averaged 11,360 AUMs for an unplanned reduction of 2% (Anderson et al. 1990).

Klebenow (1984-85) noted that in 1978 and 1980 there was sufficient precipitation during the spring and summer to maintain succulent forage on uplands of the Sheldon National Wildlife Refuge in Nevada late into the summer season and that most of the sage grouse remained on uplands throughout the summer. This suggests that, if grazing management of uplands could be designed to increase forb species and prolong production of succulent forage, benefits to sage grouse might be significant.

Something on this order may be happening on the Hart Mountain Refuge where grazing systems have benefitted the vegetation. For example, monitoring data from permanent plots on the Refuge show that, during the period 1978-87, one of the significant vegetational changes that occurred was an

increased number of perennial herbaceous species, mainly forbs. For instance, 36 new herbaceous perennial species were found on low sagebrush *(Artemisia arbuscula)* sites, which are major pronghorn kidding and sage grouse habitats, whereas 18 herbaceous species disappeared from the stands for unknown reasons.

Since the late 1950's, the productivity trend of sage grouse, as measured by chicks per hen, has varied greatly but generally has been declining on the Refuge as well as on adjacent lands off the Refuge. However, the rate of decline on the Refuge has been notably less than off the Refuge. This has been most apparent since about 1970 when the management plan was installed. The coincidence of grouse response to livestock management on the Refuge is purely conjecture now. However, evidence seems to correlate the reduced rate of decline of sage grouse productivity to the increased number and abundance of perennial forb species on upland sites and, possibly, prolonged succulent forage due to the preconditioning treatment.

Roosevelt elk and public viewing.—Preconditioning meadows to reduce depredation by Roosevelt elk on nearby agricultural lands and tree farms has been practiced on the Jewel-Beneke Creek Wildlife Management Area in the coastal mountains of northwestern Oregon since 1975. In this case, prescribed livestock grazing was inappropriate because local livestock consist mainly of high-producing dairy herds. Consequently, the meadows were preconditioned by timely mowing, baling, and removal of hay.

Roosevelt elk used these meadows during daylight hours sufficiently to attract public visitation for the purpose of viewing and photographing wild elk at reasonably close range from the public road that borders the meadows. During the period 1970-74 prior to preconditioning, 130 head of elk frequented the meadows daily during October through April. Immediately upon preconditioning in 1975, elk use increased to 300 daily and, since hunting is not allowed on this Area, it was necessary to trap and transplant elk annually in order to hold the herd size to about this level. About 60% of this local herd now uses the meadows yearlong. From 1975 through 1987 an average of 70 elk have been transplanted off the Area annually.

Visitor days before the preconditioning treatment began averaged 36,850 annually. For the period 1975 through 1987 when elk responded to preconditioning and more elk spent

more time on the meadows, average annual visitor days increased from 67,750 to 86,225 by 1987, an increase of 134% (personal communication with Frank Newton, Oregon Department of Fish and Game, Portland, Oreg., 1989).

Mule deer.—Since 1980, prescribed grazing has been practiced on the Sheldon National Wildlife Refuge in northwestern Nevada. One feature of this grazing system is that it provides for improving the nutritional value of forage for summering mule deer by manipulating cattle grazing on antelope bitterbrush *(Purshia tridentata),* a key component of deer habitat from a nutritional standpoint. The system provides for cattle to graze bitterbrush areas in the autumn no more often than every other year to improve or maintain vigor and production of new leader growth on bitterbrush, yet maintain a reasonably hedged growth form. This is based on observations and studies showing that cattle graze mainly on herbaceous species prior to late summer/autumn at which time they increase their use of palatable shrubs, including bitterbrush. On this Refuge, bitterbrush areas are important summer-autumn range for mule deer; they winter at lower elevations.

Woodis and Oldemeyer (undated) studied mule deer and cattle use of bitterbrush on the Refuge to determine their respective food habits for late spring, summer, and autumn of 1984 and 1985. A total of 4,455 bitterbrush plants were sampled in deer and cow feeding pens. Based on over 100,000 bitterbrush bites recorded for both deer and cow trials for each season, they reported that both deer and cattle took more bites for moderately and heavily hedged and fewer bites of lightly hedged bitterbrush plants than would be expected based on availability of the three hedge classes. A greater percent of moderately- and heavily-hedged plants occurred outside a 375-ha cattle exclosure than inside, suggesting that cattle were modifying growth form of bitterbrush to the possible advantage of mule deer. The nutritional value of bitterbrush in mule deer diets has been well documented.

Livestock ranching.—It would be remiss to imply by these examples that nutritional level and palatability of mature forage can be improved by prescribed livestock grazing only on public wildlife areas and for wildlife benefits. Quantified data are more readily available on such protects than on livestock ranches where similar grazing systems have been in operation and the benefits are mainly livestock oriented. How-

ever, one progressive ranching family has reported, "We have been consciously preconditioning forage for over 10 years. It not only adds six weeks to each end of the grazing season but also significantly reduces the amount of supplement needed on winter range. We notice that viable seed is produced almost every year on the early-use pasture—something that doesn't happen most years on pastures with a full seasons' growth. Our unit which shows the greatest number of new Idaho fescue and basin wildrye seedlings is one which had early spring use every year for 10 years."

"Today, November 26, we are running 260 weaner calves, born between March 10 and May 1, on preconditioned regrowth of Idaho fescue. They were weaned around August 1 and a sample test weight in mid-November showed a gain of 1 pound per head per day. It would cost about 75 cents per head per day to feed these calves in a feedlot situation. They probably are just holding even now. This opportunity, which occurs often if you are ready for it, was the result of a 3/4-inch rain in mid-September. It doesn't take much rain to do wonders if the forage is properly prepared."

"We never turn into a pasture just to use the feed. We think (1) what is grazing doing to the plant health; (2) what quality regrowth will result after we leave the unit; (3) what volume of regrowth can we expect." (Personal communication, Doc Hatfield, High Desert Ranch, Brothers, Oreg., 1989).

Summary

The questions have been asked: Can livestock be used as a tool to enhance wildlife habitat? Can forage quality be improved by prescribed grazing? The answer: A strong, but qualified, YES. There is a dire need to objectively scrutinize livestock grazing systems on public and interdependent private lands to determine if they are, in fact, improving or maintaining the vegetation from the standpoint of watershed and riparian quality, and soil movement. Are concerns for wildlife habitat and downstream fisheries consciously a part of the system's design or just incidental, if at all?

At stake is the opportunity and flexibility to continue to use livestock as a tool to restore riparian areas, watersheds and wildlife habitat no matter where they occur, private or public.

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Nesting Success of Upland Nesting Waterfowl and Sharp-tailed Grouse in Specialized Grazing Systems in Southcentral North Dakota[1]

Kevin K. Sedivec,[2] Terry A. Messmer,[2] William T. Barker,[2] Kenneth F. Higgins,[3] and Dan R. Hertel[4]

Abstract.—Nesting densities, Mayfield nesting success and duckling production were determined for each treatment by use of a chain-drag operation for nest searching. Nesting success was highest on the twice-over rotation grazing system in 1985, 1987, and 1988 with 54.6%, 49.4%, and 34.0%, respectively. Nesting success in 1986 and 1989 was highest on the short-duration grazing system with 60.8% and 36.2%, respectively. Nesting success on nongrazed prairie was consistently lower than the grazing treatments and ranged from 6.6% in 1985 to 16.3% in 1987. Twice-over rotation, short-duration and switchback grazing systems were beneficial for the mutual production of waterfowl and livestock in southcentral North Dakota.

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[2]Kevin K. Sedivec, Terry A. Messmer, and William T. Barker are Extension Rangeland Management Specialist, Extension Wildlife Specialist, and Professor of Animal and Range Science, respectively, Animal and Range Sciences Department, North Dakota State University, Fargo, ND 58105.

[3]Kenneth F. Higgins is Associate Professor of Wildlife and Fisheries Science, United States Fish and Wildlife Service, South Dakota Cooperative Fish and Wildlife Unit, South Dakota State University, Brookings, SD 57007.

[4]Dan R. Hertel is Wildlife Biologist, United States Fish and Wildlife Service, Wetlands Management District, Fergus Falls, MN 56537.

Recent declines in numbers of several waterfowl species (U.S. Fish and Wildlife Service 1986, U.S. Fish and Wildlife Service and Canadian Wildlife Service 1988) and low nesting success rates may indicate insufficient duck reproduction in the Prairie Pothole Region (PPR) to maintain populations at current levels (Klett et al. 1988). About 50% of all North American ducks are produced on the PPR, and 95% of those ducks are produced on private lands (Smith et al. 1964). Thus, efforts to reverse the decline in duck numbers should emphasize the use of new and improved management techniques on private lands.

Rangelands, comprising over 30% of the land area in North Dakota, are the primary producers of upland nesting birds on private lands in North Dakota and elsewhere in the PPR. Rangelands are the primary source of feed for livestock and grazed extensively from 15 May to 15 November in North Dakota. However, rangelands are declining in extent (North Dakota Conservation Needs Inventory 1970).

Komarek (1969) stated that manipulation of vegetation to influence animal populations is the basis of wildlife habitat management. Grazing is one of several management options that can be used to manipulate upland nesting habitat while maintaining maximum livestock production. Seasonlong grazing is detrimental to production of most upland nesting birds (Kirsch et al. 1978) and also to maximum livestock production (Barker and Nyren 1988, Kirby and Nyren 1988).

Limited research has been reported on wildlife population declines or benefits from livestock grazing systems. The purpose of our study was to determine if typical upland nesting birds utilized a mixed grass-prairie differently among complementary, seasonlong, short-duration, switchback, and twice-over rotation grazing treatments, and idle native rangeland. If differences in use do exist, compare the effects of differing grazing management designs, cover availability, and nest site selection and identify grazing systems that may benefit both upland nesting birds and livestock production.

Study Area

Research was conducted on the Central Grasslands Research Center, approximately 65 km southwest of Jamestown, ND,

within the Missouri Coteau physiographic region (Nyren 1986). The station is generally characterized by "hummocky," irregular, rolling plains containing numerous wetlands and potholes, with a poorly integrated natural drainage system (Lura 1985). At maximum capacity, wetlands comprise approximately 9% of the total station area (Lura 1985). Wetlands are classified as being ephemeral, temporary, and seasonal (Stewart and Kantrud 1971).

The mixed grass-prairie has a typical vegetation (Whitman and Wali 1975, Barker and Whitman 1988, Lura et al. 1988, Barker and Whitman 1989). Kuchler (1964) classified the natural vegetation of this mixed grass prairie as a moderately dense, short to medium tall wheatgrass-needlegrass *(Agropyron-Stipa)* association. Important grasses and sedges (graminoid species) include western wheatgrass *(Agropyron smithii)*, blue grama *(Bouteloua gracilis)*, Kentucky bluegrass *(Poa pratensis)*, smooth bromegrass *(Bromus inermis)*, needle-and-thread *(Stipa comata)*, green needlegrass *(Stipa viridula)*, prairie Junegrass *(Koeleria pyramidata)*, and thread-leaf sedge *(Carex filifolia)* (Lura et al. 1988). Important broad-leafed herbs (forbs) include fringed sage *(Artemisia frigida)*, white sage *(Artemisia ludoviciana)*, silver-leaf scurf pea *(Psoralea argophylla)*, red false globemallow *(Sphaeralcea coccinea)*, Canada anemone *(Anemone canadensis)*, and goldenrods (*Solidago* spp.) (Lura et al. 1988). Western snowberry *(Symphoricarpos occidentalis)* is the dominant shrub on mesic sites.[5]

Seven major range sites are classified on the study area (Lura et al. 1988). Overflow and silty range sites dominated the study area, occupying over 85% of the land cover. Other range sites found on the station include wet meadow, thin-upland, shallow-to-gravel, very shallow and wetland.

Overflow range sites occur on nearly level swales and depressions and on residual and glacial uplands. Slopes are commonly from 1% to 3%. Soils are deep, well drained, medium, and moderately fine textured that regularly receive additional run-in from higher land. Vegetation dominating this range site on the station include western snowberry, Kentucky bluegrass, smooth bromegrass, goldenrods and yarrow.

Silty range sites occur on nearly level to strongly sloping glacial till uplands. Slopes are commonly from 1% to 15%. Soils

[5]Plant nomenclature follows the Great Plains Flora (Great Plains Flora Association 1986).

are deep, well and moderately drained, medium and moderately fine textured. Vegetation dominating this site on the station include green needlegrass, needle-and-thread, blue grama, little bluestem, Junegrass, western wheatgrass, Kentucky bluegrass and sun sedge.

North Dakota has a continental climate characterized by warm summers and cold winters. January is the coldest month with an average temperature of -14° C and July is the warmest with an average temperature of 20° C (Ramirez 1972). The mean annual precipitation for a 37-year period on the study area is 44.7 cm (17.6 in), with 80% falling between April and September (Sedivec 1989). The annual precipitation was 58.4, 48.0, 50.3, 45.6, 69.1, 45.6, 19.5, 46.7 cm in 1982 through 1989, respectively (Central Grasslands Research Center, Annual Review, 1982-1989). A drought began in September 1987 that greatly reduced range forage production in 1988. The average length of the freeze-free period for this area of North Dakota is 120-125 days (Ramirez 1972).

Methods

Grazing Treatments

Five grazing treatments and a nongrazed, idle area were evaluated in this study. All treatment and idle areas were contiguous, with similar topography and predator influences. The station consisted of 2160 ha of which 1362 ha are rangeland. The idle area in Section 24 consisted of 130 ha that was last grazed in 1979. Twenty hectares were mowed in September 1985 and all 130 ha were mowed in mid-July 1988. No data was collected the following year on lands that were mowed.

Section 25 (259 ha) was divided equally in 1982 into seasonlong and short-duration grazing treatments. The seasonlong pasture has been grazed by one cattle herd at the recommended stocking rate of 1.8 AUM/ha (U.S. Soil Conservation Service 1984) since 1984, excluding 1988 (table 1). Livestock were free to graze any area within the 130 ha seasonlong pasture.

The short-duration grazing system consisted of eight 16.2 ha pastures grazed by one cattle herd at a stocking rate of 2.7

AUM/ha since 1984, excluding 1988 (table 1). An increase in fencing and herd management compared to seasonlong grazing is required in the short-duration grazing system. Each of eight pastures in this system were grazed for five days during the four rotations during the grazing season, with 35 days rest between rotations. In 1989 the grazing period between rotations varied, beginning with three days and followed by four days, six days and seven days per rotation. The number of days rest ranged from 21 on the first rotation to 49 on the last rotation.

Section 31 was divided equally in 1985 and managed as two replications of the twice-over rotation grazing system. This system involves more fences and herd management than seasonlong grazing, but much less than the short-duration grazing system. Each replication consisted of four 32.4 ha pastures which were each grazed by one cattle herd at a stocking rate of 2.7 AUM/ha since 1986, excluding 1988 (table 1). Each pasture was grazed for 20 days and then rested for 60 days during each of two rotations. In 1983 and 1984 each replication consisted of three 32.4 ha pastures grazed by one herd at a stocking rate of 2.2 and 2.4 AUM/ha in 1983 and 1984, respectively. Each pasture was grazed for 28-day periods and then rested for 56 days during each of two rotations.

Table 1.—Grazing seasons, cow/calf pairs, and stocking rate (AUM/ha) for grazing treatments at the Central Grasslands Research Station, North Dakota.

		Seasonlong		Short duration		Twice-over rotation		Switchback	
Year	Date	Pairs	Rate AUM/ha	Pairs	Rate AUM/ha	Pairs	Rate AUM/ha	Pairs	Rate AUM/ha
1982	6/15-11/2	30	1.1	45	1.6	0	—	0	—
1983	6/2-11/8	40	1.6	60	2.4	40	2.2	0	—
1984	6/5-11/5	45	1.8	65	2.7	45	2.4	0	—
1985	5/28-11/4	45	1.8	65	2.7	60	2.4	0	—
1986	5/23-10/31	45	1.8	65	2.7	65	2.7	16	2.6
1987	5/28-11/3	45	1.8	65	2.7	65	2.7	16	2.6
1988	5/24-9/1	46	1.2	65	1.6	65	1.6	16	1.6
1989	5/23-10/27	46	1.8	65	2.7	65	2.7	16	2.6

Note: Dashes indicate no data collected; treatment did not exist.

In 1987 two replications of a switchback grazing system were implemented on a 64.8 ha plot in Section 30, adjacent to the short-duration grazing system. This system involves similar herd management as the twice-over rotation grazing system, but only half the fencing. Each replication consisted of two 16.2 ha pastures and was grazed by one herd at a stocking rate of 2.6 AUM/ha. In 1988 the stocking rate was 1.6 AUM/ha. Each pasture was grazed for 20-day periods and then rested for 20 days during each of four rotations.

In 1985 a complementary grazing system was implemented on 68.8 ha of Section 14. This system consisted of three domesticated grass pastures and one native pasture. Livestock began grazing in a 12.1 ha crested wheatgrass *(Agropyron desertorum)* pasture and were then rotated sequentially to a 32.5 ha native pasture, a 12.1 ha Russian wildrye grass *(Elymus junceus)* pasture, and a 12.1 ha altai wildrye grass *(Elymus angustus)* pasture. The stocking rates were 2.5 and 2.4 AUM/ha in 1985 and 1986, and 2.8 and 2.1 AUM/ha in 1987 and 1989, respectively (table 2).

Nest Searches

Nest searches were conducted between 1 May and 15 July, 1984 through 1989. Four searches were made at three week intervals in 1984, 1987, 1988, and 1989. Three nest searches were conducted at four week intervals in 1985 and 1986. Five searches were conducted at 18-day intervals in 1983 between 15 April and 10 July. Nest searches were performed between 7:00 A.M. and 1:00 P.M. CST, since that time period has the highest probability of the hen being on the nest (Klett et al.

Table 2.—Grazing season, cow/calf pairs, and stocking rate (AUM/ha) for a complementary grazing system at the Central Grasslands Research Station, North Dakota.

		Complementary	
Year	Date	Pairs	Rate AUM/ha
1985	4/23-11/21	25	2.5
1986	4/23-11/9	25	2.4
1987	4/24-11/2	30	2.8
1988	4/27-8/15	26	1.4
1989	4/28-10/12	26	2.1

1986). Nests were found by dragging a 8-mm diameter, 30.5 m long chain between two 200 cc all terrain cycles as illustrated by Higgins et al. (1969, 1977), with the exception of using a single chain compared to a cable-chain.

Each site from which a duck flushed was examined and was considered a nest if at least one egg was present. Study area, species identification, number of eggs, stage of embryo development (Weller 1956), cover diversity, and dominant plant species were recorded on nest cards developed and provided by the Northern Prairie Wildlife Research Center, Jamestown, ND. Nest initiation dates were determined by subtracting the sum of the number of eggs laid plus days of embryo development from the date the nest was found. This date was that time period when first egg was laid. The average of four visual obstruction readings (VORs) modified from Robel et al. (1970) was recorded at each nest site. Difference in Robel's techniques was the use of a 5–cm diameter pole marked at 1/4–dm increments. Nests were marked with a small flag placed 4 m away. Nest sites were also plotted on an aerial photograph to aid in relocating and revisiting nests. Nests were revisited every 7-10 days and those nests in which at least one egg hatched were classified as successful.

Vegetation Sampling

Visual obstruction readings (VORs) (Robel et al. 1970) were used to determine a height and density index of the vegetation at each of the management treatment sites. Readings to the nearest 1/4 dm were recorded systematically from permanent transects devised by Messmer (1985). These transects were proportionately allocated on the basis of range sites present within each treatment (table 3). Each transect lay in a north-south direction from fenceline to fenceline and contained 25 stations 30 paces apart. The VORs on each transect were averaged and partitioned per range site.

VORs were conducted twice each field season per range site. Residual vegetation was determined by sampling each treatment in mid-April. Green-up vegetation was sampled in late May to early June prior to grazing.

VORs were also recorded at each nest site at the time when nests were found. The average VOR of each nesting species was determined and then correlated with the VORs recorded for

each range site on each treatment. Preferred nesting cover availability was determined for each treatment.

Estimates of Nest Success

Predicted daily nest survival rates were calculated for each treatment and duck species using the Mayfield (1961, 1975) method as modified by Johnson (1979). Apparent nesting success was used to calculate the survival rates of sharp-tailed grouse due to small sample size. Nests were excluded from analysis if bird abandoned the nest due to nest search activities, if nests were destroyed by nest search activities, or if nests were unable to be relocated.

Nest success was calculated by raising the models predicted daily nest survival rate (1—number unsuccessful nests/exposure days) to a power equal to the mean laying plus incubation periods for successful clutches. We used 35-day incubation periods for mallards *(Anas platyrhyncos)* and redheads *(Aythya americana)*; 34 days for blue-winged teal *(Anas discors)*, gadwalls *(Anas strepera)*, American wigeon *(Anas americana)*, green-winged teal *(Anas crecca)*, lesser scaup *(Aythya affinis)* and northern shovelers *(Anas clypeata)*; and 33 days for north-

Table 3.—Percentage of various range sites by five grazing treatments and one idle area at the Central Grasslands Research Station, North Dakota.

Treatment	Size (ha)	Overflow[1]	Silty	Sites	Wetland[2]	Reseeded[3]
Short duration	130	49.6	46.3	—	4.1	—
Seasonlong	130	43.5	49.9	3.5	3.1	—
Switchback	65	40.3	49.5	10.2	10.2	—
Twice-over rotation	259	20.7	59.0	6.3	6.3	10.5
Complementary	69	18.9	25.0	4.2	4.2	50.0
Idle area	85	75.2	8.8	14.1	14.1	—

[1]*Overflow sites include wet meadow range sites.*

[2]*Wetland percentages include basins at 100% capacity.*

[3]*Reseeded vegetation on the twice over rotation and complementary grazing system consisted of a native grass species mix and a domesticated grass, respectively.*

Note: Dashes indicate no data collected; treatment did not exist.

ern pintails *(Anas acuta)*. Nest success estimates were obtained from the weighted means of constituent estimates. Weighting was necessary to account for the variability of duck species among the grazing treatments and the idle area. Apparent nest success was calculated by taking the number of successful nests divided by the total nests found times 100.

Sharp-Tailed Grouse Census

A census of sharp-tailed grouse on and within a 1.6 km radius of station boundaries was conducted during April each year following procedures by Grange (1948) and Kirsch (1956). Grouse dancing grounds (leks) were located during listening runs in late March each year. On-site censusing of males only was conducted at least three times per ground between 1 April and 15 May from 1983 through 1989.

Livestock and Herbage Performance

Herbage performance data was collected by use of paired plots by the North Dakota State University Animal and Range Sciences Department and the North Dakota Agricultural Experiment Station since 1982. Silty and overflow range sites were selected for vegetation sampling. Portable exclosure cages (0.8 x 1.5 m) were placed in each treatment and paired grazed and ungrazed caged plots clipped throughout the grazing season. The initial clipping plus growth in the caged plots were used to estimate herbage yield. Herbage utilized by cattle from grazed plots were used to determine percentage utilization.

Livestock were randomly sorted and weighed on and off grazing treatments to obtain average daily gain (ADG) and average gain (AG) per hectare for calves. Additional weights were taken at 84 days after the initial weighing and every 28 days thereafter. The experimental livestock breed consisted of Hereford-Angus-Gelbvieh cross.

Results and Discussion

Nest Numbers

Nine duck species were found nesting on the station. Of the 1,601 duck nests found 36.1% were blue-winged teal, 22.9%

gadwall, 17.9% mallard, 13.1% northern pintail, 5.6% northern shoveler, 1.9% American wigeon, 1.6% lesser scaup, 0.7% green-winged teal, and 0.2% redhead.

Nesting Density

Nest densities were highest in idle, nongrazed native prairie on the station in 1983, 1984, 1985, and 1988; in the short-duration grazing system in 1986 and in the switchback grazing system in 1987 and 1989 (table 4). Nest densities in the idle area ranged from 2.4 times greater than the grazing treatments in 1983 to an equal density in 1987. For all seven years, the idle area averaged nest densities were 1.6 times greater than all grazing treatments combined.

Nest densities alone should not be used to determine the success of a treatment. Densities do not vary only with cover availability, but also vary with water availability, land topography, and range site. Nesting success rates and density must be combined when determining the value of a treatment to waterfowl or conclusions may be biased.

Duck nesting densities were highest in the twice-over rotation grazing system when comparing only the grazing treatments in 1983, 1984, 1985, and 1988. The short-duration grazing system had the highest nest densities in 1986 while the switchback grazing system had the highest densities in 1987 and 1989. Nesting densities varied with the location of wet-

Table 4.—Density of duck nests found per 40.5 ha on the various grazing treatments and idle area at the Central Grasslands Research Station in 1983-1989.

Treatment	1983	1984	1985	1986	1987	1988	1989	Avg.
Seasonlong	4.3	7.1	3.7	5.3	24.4	11.9	10.6	9.6
Short duration	9.0	15.4	5.0	11.7	27.8	14.4	7.8	13.0
Twice-over rotation	11.9	15.6	7.6	9.6	18.6	15.9	12.8	13.2
Complementary	—	—	4.1	4.7	10.0	3.5	5.9	5.6
Switchback	—	—	—	—	30.3	13.0	13.8	19.0
Idle area	22.1	26.7	10.4	11.1	23.3	18.6	—	18.7

Note: Dashes indicate no data collected; treatment did not exist.

lands and overflow range sites, the amount of residual vegetation, and the amount of undisturbed cover during the critical nesting period.

Wetlands are essential for attracting breeding and nesting waterfowl on the mixed grass-prairies. The idle area and the switchback grazing system contained 14% and 10% standing water, respectively, as compared to 6% on the twice-over rotation, 4% on the short duration, 4% on the complementary, and 4% on the seasonlong grazing treatments when basins were at full capacity. The idle area and switchback grazing system, containing the highest percentage of standing water, attracted more ducks and contained the highest nesting densities in six of seven years. On the average, most blue-winged teal and lesser scaup nested mainly near water, whereas mallards, northern pintails, gadwalls, northern shovelers, and American wigeons nested both near water and as far as 1.5 km from water (Sedivec 1989). Ducks may have been attracted to one treatment because of water availability but nested in another treatment with better vegetative cover or less disturbance by livestock and predators.

Residual vegetation in the spring is an important habitat for early nesting ducks such as mallards and northern pintails (Kirsch et al. 1978). Residual vegetation cover was an important component for nest site selection in our study. The idle area had significantly more ($P<0.05$) residual cover than all the grazing treatments from 1983 through 1988 (table 5). Mean residual cover VORs among seasonlong, short-duration, and twice-over rotation grazing treatments were not different ($P>0.05$) in 1983, 1984, 1988, and 1989.

Range Site Selection

Nest site selection was studied from 1985 to 1989 among overflow, wet meadow, silty, thin-upland, and shallow-to-gravel range sites, and reseeded grasslands. Of 1,119 nests, 77.8% were initiated in overflow range sites (table 6). Mallards and northern pintails chose the overflow range sites for 93.0% and 73.0% of their nesting attempts, respectively. Overflow range sites were used for 75.2% of nest initiations by all other duck species, indicating that areas with higher percentages of overflow range sites are more attractive to nesting ducks than other range sites within mixed-grass prairie rangelands.

The annual grazing season began in late May on the station. The average beginning date between 1983 and 1989 was May 28. Over 57% of 1,198 nests found from 1983 to 1989 were initiated before the grazing season (table 7). Twenty-seven point seven percent of all nests found were initiated in ungrazed pastures during the grazing season, 12.9% while cattle were present, and 2.1% on pastures after cattle were rotated. When comparing only those nests initiated in grazing treatments after the grazing season began, 65.0% of the clutches were started on pastures that were free of cattle during that period of the overall rotation, 30.2% started on pastures containing cattle, and 4.8% on pastures after cattle were rotated.

Table 5.—Mean residual cover VORs measured to the nearest 0.25 dm on the various grazing treatments and idle area at the Central Grasslands Research Station in 1983 through 1989.

Treatment[1]	1983	1984	1985	1986	1987	1988	1989	Avg.
Seasonlong	0.6^{b}	0.4^{b}	0.8^{b}	0.7^{b}	1.1^{b}	1.0^{b}	0.5^{a}	.73
Short duration	0.5^{b}	0.4^{b}	0.7^{bc}	0.5^{d}	1.0^{bcd}	0.8^{b}	0.5^{a}	.63
Twice-over rotation	0.5^{b}	0.4^{b}	0.6^{c}	0.6^{c}	0.9^{d}	0.9^{b}	0.5^{a}	.63
Complementary	—	—	0.4^{d}	0.6^{c}	0.9^{cd}	0.9^{b}	0.4^{a}	.62
Switchback	—	—	—	—	1.1^{bc}	0.9^{b}	0.4^{a}	.80
Idle area	1.2^{a}	1.2^{a}	1.3^{a}	1.3^{a}	1.7^{a}	1.7^{a}	—	1.40

[1] *Treatment VORs bearing different superscripts are significantly different ($P<0.05$) within treatments by year.*

Note: Dashes indicate no data collected; treatment did not exist.

Table 6.—Comparison of duck nest site selection (percentages) among range sites at the Central Grasslands Research Station for years 1985 through 1989.

Species	Number of nests	Overflow	Silty	Other
Mallard	210	93.0	5.0	2.0
Northern pintail	147	73.0	23.8	3.2
Gadwall	285	84.3	11.8	3.9
Blue-winged teal	357	68.1	29.5	2.4
Others	120	74.5	20.0	5.5
Total	1119	77.8	19.3	2.9

Rest intervals between rotations varied among the grazing systems. The twice-over rotation grazing system allowed for 60 days rest between rotations, leaving 75% of the land ungrazed in mid-June and 50% ungrazed in early July. Over 37% of the nests found on the twice-over rotation grazing system were initiated in ungrazed pasture during the grazing season (table 7). The short-duration grazing system allowed 35 days rest between rotations, leaving 50% of the treatment ungrazed in mid-June, and 29.2% of the nests in this system found in ungrazed pastures. The switchback grazing system allowed 20 days of rest between rotations, being completely disturbed by mid-June and 12% of the nests found were in ungrazed pastures. Ducks did initiate nests while cattle were present in a pasture (table 7), particularly in pastures 32 ha or larger. The short-duration grazing system had a small number of nests initiated while cattle were present due to small pasture size and large herd size.

Nesting Success

Nesting success was highest on the twice-over rotation grazing system in 1984, 1985, 1987, and 1988 and highest on the short-duration grazing system in 1983, 1986, and 1989 (table 8). Nesting success on the idle area ranged from 6.6% in 1983

Table 7.—Percentage of duck nests initiated on the entire grazing treatment before the grazing season, in ungrazed pastures, while cattle were present, and after cattle were rotated on the grazing treatments at the Central Grasslands Research Station for all years 1983 through 1989.

Treatment	Total nests	Before grazing season	Ungrazed pasture	While cattle present	After cattle rotated
Seasonlong	216	61.1	—[1]	38.9	—
Short duration	293	67.7	29.2	1.8	4.9
Twice-over rotation	549	54.9	37.2	6.9	0.9
Complementary[2]	48	0.0	75.0	25.0	0.0
Switchback	92	64.1	12.0	17.4	6.5
Avg. of all treatments	1198	57.1	27.9	12.9	2.1

[1] *Opportunity for ungrazed pastures and pastures after cattle are rotated do not occur in seasonlong pastures.*

[2] *Grazing season began approximately 30 days before the other treatments.*

to 16.3% in 1985 and 1987. Nesting success on the twice-over rotation grazing system was consistently higher than on the seasonlong treatment, with the exception of 1986. Short-duration and seasonlong grazing treatments had a similar duck nesting success on the average for all years. Switchback grazing system had a higher nesting success compared to the seasonlong treatment in all years except 1989.

Cowardin et al. (1985) suggested that a Mayfield nesting success of 15.2% was needed to maintain a waterfowl (mallard) population. The idle area maintained a population in two of six years, the twice-over rotation grazing system in seven of seven years, the short-duration grazing system in six of seven years, the seasonlong grazing treatment in three of seven years, and the switchback grazing system two of three years.

The twice-over rotation grazing system had the highest number of successful nests per 40.5 ha in 1984, 1985, 1988, and 1989 while the short-duration grazing system had the highest in 1986 and 1989 (table 9). Overall, the twice-over rotation, short-duration, and switchback grazing systems consistently produced as many or more successful nests per 40.5 ha than the seasonlong grazing treatment.

Sharp-Tailed Grouse

Forty-two grouse nests were found in 1983, 1984, 1987, 1988, and 1989. Twenty-one (50%) of these nests were found

Table 8.—Percent Mayfield duck nesting success occurring on the grazing treatments and idle area at the Central Grasslands Research Station, 1983 through 1989.

Treatment	1983	1984	1985	1986	1987	1988	1989	Avg.
Treatment	1983	1984	1985	1986	1987	1988	1989	Avg.
Seasonlong	12.0	11.7	40.3	52.8	41.3	14.7	13.3	26.6
Short duration	22.0	1.0	17.9	60.8	25.4	22.7	36.2	25.6
Twice-over rotation	17.0	31.4	54.6	43.2	49.3	34.0	16.4	34.7
Complementary	—	—	8.0	20.8	8.7	3.3	3.2	8.8
Switchback	—	—	—	—	29.8	17.4	11.9	22.7
Idle area	6.6	13.6	16.3	7.0	16.3	7.0	—	11.3

Note: Dashes indicate no data collected; treatment did not exist.

in the twice-over rotation grazing system at an average density of one nest per 55.5 ha. Apparent nesting success ranged from 0.0% in 1983 to 80.0% in 1987 and averaged 55.6%. All the nests found were initiated before the grazing season began (fourth week in May) or were in ungrazed pastures during rotations in this system.

Six grouse nests were found in the short-duration grazing system for an average of one nest per 107.9 ha. Apparent nesting success ranged from 0.0% in 1983 to 100% in 1989, and averaged 33.3%. All nests found were initiated before the grazing season in this system.

Three grouse nests were found in the seasonlong grazing system for an average of one nest per 215.8 ha. Apparent nesting success ranged from 0.0% in 1983 to 100% in 1988 and 1989 and averaged 66.7%. All the nests found were initiated before the grazing season in this system.

Eleven grouse nests were found in the idle, nongrazed areas for an average of one nest per 47.2 ha. Apparent nesting success ranged from 0.0% in 1984 to 50.0% in 1988 and averaged 22.2%.

Average VORs at successful grouse nests (1.82 dm) were higher but not significantly different ($P<0.05$) than at nests destroyed by predators (1.74 dm). Predators destroyed 20 nests (55.6%) and nest searching operations destroyed five nests.

Nest densities and apparent nesting success for grouse differed among range sites. Thirty-two (66.7%) of 41 nests were

Table 9.—Number of successful duck nests per 40.5 ha on the grazing treatments and idle area at the Central Grasslands Research Station from 1983 to 1989.

Treatment	1983	1984	1985	1986	1987	1988	1989	Avg.
Seasonlong	1.2	2.0	2.2	3.7	14.7	4.4	3.8	4.6
Short duration	2.4	0.3	2.2	9.1	12.8	5.9	4.4	5.3
Twice-over rotation	3.6	6.8	5.8	5.6	11.4	8.8	4.4	6.6
Complementary	—	—	1.2	2.3	1.8	0.6	1.2	1.4
Switchback	—	—	—	—	15.0	4.4	3.8	7.7
Idle area	5.6	6.0	3.7	8.3	8.6	3.3	—	5.9

Note: Dashes indicate no data collected; treatment did not exist.

found in overflow range sites, 12 (25.0%) in silty sites, and four (8.3%) in reseeded cover. Successful rates averaged 34.4% for nests found in overflow sites, 33.3% in silty sites and 25.0% in reseeded cover.

Livestock and Herbage Performance

Average daily calf gain (ADG) for the years 1985 through 1989, approximately 1.0 kg/day, was similar among all grazing treatments. Average calf gain per ha (AG/ha) was lower on the seasonlong grazing treatment than on the twice-over rotation, switchback, short-duration, and complementary grazing systems (table 10) (Animal/Range Science Annual Reports 1982-1989). Higher stocking rates on the twice-over rotation, short-duration, complementary, and switchback grazing systems account for the higher AG/ha than the seasonlong grazing.

Higher stocking rates are possible on the rotational grazing systems because of the rest periods from grazing and better livestock distribution during rotations. We used herbage utilization data to justify the stocking rates on the various grazing systems. Generally, range specialists and scientists suggest that 50% to 60% of the vegetation should be grazed annually for proper range use. For the years 1985 through 1989, average herbage utilization ranged from 54% on the seasonlong and

Table 10.—Herbaceous production and utilization, and livestock performance in average daily calf gain (ADG), and average gain (AG) on the various grazing systems at the Central Grasslands Research Station from 1985 to 1989.

System		Herbage: Production kg/ha	Herbage: Utilization %	Calves: ADG kg	Calves: AG kg/ha
Seasonlong	Avg.	3207	54	1.05	49
	Range	1717-4533	47-59	0.95-1.27	36-66
Short	Avg.	3063	62	1.05	68
duration	Range	1499-4324	52-75	0.95-1.27	53-90
Twice-over	Avg.	2892	54	1.09	70
rotation	Range	1543-3876	48-63	1.00-1.23	51-88
Comple-	Avg.	2200	59	1.05	66
mentary	Range	871-2839	54-71	0.95-1.23	41-77
Switchback	Avg.	3617	57	1.09	68
	Range	2273-4526	53-64	0.95-1.27	54-87

twice-over rotation grazing treatments to 62% on the short-duration grazing system (table 10). Thus, proper range use occurred among all of the grazing treatments during the study.

The grazing system began on the third to fourth week in May which benefits the native grass species. Rogler et al. (1962) and Whitman et al. (1951) showed a negative response in herbage production when grazing in May. Domestic or tame grass pastures are recommended for early season grazing to allow native grass species to mature and provide greater herbage production for livestock and enhance nesting cover for ground nesting birds.

Summary and Conclusion

Cattle grazing has continually had a positive impact on enhancing waterfowl nesting habitat in southcentral North Dakota, when properly managed. Grazed rangeland provided safer nesting cover in all years of the study when compared to idle, nongrazed areas. Ducks initially chose nesting in undisturbed cover of the grazing treatments but continued initiating nests while the cattle were present.

Mean production rates in specialized grazing systems exceeded seasonlong grazing in waterfowl, sharp-tailed grouse, and livestock production. A major advantage of the twice-over rotation, short-duration, switchback, and complementary grazing systems over seasonlong grazing is the control in timing of grazing to best benefit the grass plants which provide nesting habitat. Once cattle are placed on the seasonlong treatment, the entire pasture can be disturbed, either by grazing effects on cover or cattle presence; however, waterfowl continued to nest on the seasonlong pasture even after cattle began grazing, over 38% of the nests. Cattle did not affect nest site selection unless pastures were small and herd size was large, such as in the short-duration grazing system.

Livestock production also averaged higher on the twice-over rotation, short-duration, switchback, and complementary grazing systems than on seasonlong grazing. Obviously there was no livestock production on the idle area, but neither was there any waterfowl production enhancement on the idle area over the grazed areas with the exception of the complementary grazing system.

Overflow range sites combined with western snowberry had been recognized as an essential component in nest site selection for upland nesting ducks in southcentral North Dakota. Over 77% of all duck nest sites occurred in overflow range sites on the station from 1985 to 1989. Thus, overflow range sites are important to habitat preservation and management strategies.

The grazing systems, including those having the lowest duck production, still exceeded reported production on intensively tillage croplands (Higgins 1977). Cropland is the other alternative on private lands in much of the PPR.

Management Recommendations

We offer the following management recommendations from this study:

1. In order to mutually benefit both duck and livestock production, cattle should not begin grazing on North Dakota "native" rangeland until after the third or preferably fourth week in May, the suggested starting dates for grazing native vegetation in North Dakota (Central Grasslands Research Station Annual Review 1988). Temporal delays or deferment of the initiation of grazing will benefit waterfowl by allowing over 50% of the ducks to initiate nests before grazing begins. Delayed grazing will also have the added benefit of improving range condition for livestock and providing undisturbed residual cover for early nesting ducks. Grazing earlier may reduce forage production 43% to 76% (Whitman et al. 1951, Rogler et al. 1962).

2. Overflow range sites generally contain considerable western snowberry *(Symphoricarpos occidentalis)*. Livestock producers often consider controlling snowberry because of potential losses in herbage production of desirable grasses. However, several cool-season grasses grow well in the shade of snowberry and provide early livestock forage and wildlife cover. Many ducks and sharp-tailed grouse select these sites for nesting. The snowberry areas should be retained.

3. Of the five grazing treatments evaluated in this study, we would first recommend the use of the twice-over rotation grazing system because it is better for mutual production of waterfowl, sharp-tailed grouse and livestock on private and public rangelands in southcentral North Dakota. Our reasons include: (a) twice-over rotation grazing requires less intense management and less fencing than short-duration grazing; however, similar management intensities are required for switchback grazing systems under the conditions of this study; (b) the twice-over rotation grazing system has a higher stocking rate than seasonlong grazing, but the same rate as short-duration and switchback grazing systems under the conditions of this study; (c) over 50% undisturbed areas of cover are available until early July in the twice-over rotation grazing system while 50% undisturbed cover is available until mid-June in the short-duration grazing system, and no undisturbed cover is available after mid-June in the switchback grazing system; and (d) on the average, the twice-over rotation grazing system supported the highest duck and livestock production values throughout our study, and the short-duration grazing system was a close second under the conditions of this study.

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Effects of Vegetation Manipulation on Breeding Waterfowl in Prairie Wetlands—A Literature Review[1]

Harold A. Kantrud[2]

Abstract.—Literature on the effects of fire and grazing on the wetlands used by breeding prairie waterfowl is reviewed. Both dabbling and diving ducks and their broods prefer wetlands with openings in the marsh canopy. Decreased use is commonly associated with decreased habitat heterogeneity caused by tall, robust hydrophytes such as *Typha* spp. and other species adapted to form monotypes in the absence of disturbance. Nearly all previous studies indicate that reductions in height and density of tall, emergent hydrophytes by fire and grazing (unless very intensive) generally benefit breeding waterfowl. Such benefits are an increase in pair density, probably related to increased interspersion of cover and open water which decreases visibility among conspecific pairs, and improvements in their invertebrate food resources that result from increased habitat heterogeneity. Research needs are great because of the drastic changes that have accrued to prairie wetlands through fire suppression, cultivation, and other factors. The physical and biological environments preferred by species of breeding waterfowl during their seasonal and daily activities should be ascertained from future studies in wetland complexes that exist in the highest state of natural preservation. Long-term burning and grazing experiments should follow on specific vegetatively-degraded wetlands judged to be potentially important breeding areas. Seasonality, frequency, and intensity of treatments should be varied and combined and, in addition to measuring the response of the biotic community, the changes in the physical and chemical environment of the wetlands should be monitored to increase our knowledge of causative factors and possible predictive values.

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[2] *Wildlife Research Biologist, U. S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, P.O. Box 2096, Jamestown, North Dakota 58401*

The natural forces of climate, grazing, and fire were once the major factors controlling the abundance and species composition of vegetation in prairie wetlands. Breeding and migrant birds that used the wetlands evolved successfully under these influences, as evidenced by numerous accounts of large numbers and varieties of water birds present under pristine conditions.

Although wetland drainage has received the most publicity, other activities of European man had greatly changed prairie wetlands by the end of the 19th century. Domestic animals confined within fences sometimes grazed wetlands almost year-round. Wetlands near farmsteads often became highly eutrophic from barnyard and feedlot runoff water. Prairie fires, feared by both farmers and cattlemen, were suppressed whenever possible, which allowed dead vegetation to accumulate in many wetlands. In agricultural areas, bottom soils of the shallowest, least permanent wetlands were regularly cultivated, even during wet years. In some years, wetlands with moderate water-retention ability could also be cultivated. During drought years, the bottom soils of more permanent water bodies were used to raise crops. The vegetation in all or part of some wetlands was mowed as often as possible for hay or bedding for livestock. Some wetlands were burned in the fall to reduce the amount of snow trapped in the basin or to discourage the spread of weeds; these wetlands could sometimes be cultivated the following spring.

In recent decades, cultivation of steep slopes, use of row crops, and the practice of summer fallowing have caused much topsoil to move into the basins of countless prairie wetlands, further changing their vegetative species composition and abundance. Dissolved salts and residues from agricultural chemicals probably have moved into many prairie wetlands. Irrigation practices have also altered the hydrology and vegetation of prairie wetlands. Finally, both herbage and woody vegetation have increased greatly in many wetlands in the eastern portion of the prairie pothole region. In this area, much livestock raising has been discontinued; thus, many formerly grazed or hayed wetlands that remain undrained now lie idle.

Although these land-use practices have undoubtedly affected the value of prairie wetlands to waterfowl and other birds, especially on privately owned lands, the effects have

been only slightly less severe on many wetlands owned or managed by conservation agencies.

Research has emphasized bird habitat use, behavior, food habits, and recruitment of prairie-nesting waterfowl. Techniques used to manage upland nesting cover and, to a lesser degree, to control rates of hen and egg predation at upland sites are now fairly well developed. Yet little is known about practices that can rejuvenate vegetatively degraded prairie wetlands and restore their attractiveness to breeding waterfowl and other marsh and aquatic birds.

Wildlife problems associated with vegetation in wetlands and the response of wetland vegetation and animal populations to fire and grazing by domestic livestock are reviewed in this paper.

Weller (1978) stated that the theoretical basis for present marsh management techniques for wildlife is weak because of poor experimental design and inadequate evaluation of results; he encouraged the adoption of community-oriented management systems based on natural successional patterns that give benefits for a longer time and at lower cost than artificial systems. He identified burning and grazing as the systems most in need of study. Murkin (1979) also urged that the natural processes involved in the marsh cycle be studied; he stressed the importance of determining if semi-open marsh can be maintained in a productive state.

The natural fluctuation of water levels is probably the most important cause of vegetative change in prairie wetlands. Control of water levels has been extensively used to manipulate vegetation on many areas in the United States, but is not discussed here because such control is possible on only a small portion of the publicly owned wetlands in the prairie pothole region. Artificial management with costly herbicides, explosives, and sophisticated mechanical devices is also not considered here.

Problems

Physical characteristics of wetland vegetation to aquatic birds was first given specific attention by Beecher (1942), who also found a correlation between numbers of plant communities and bird nests found in an Illinois wetland. Still, little is

known of the relations between physical and biological factors of wetlands and their effect on waterfowl (Poston 1969a). Perhaps the most widely recognized evidence of the sensitivity of marsh birds to changes in the structure and density of wetland vegetation is the generally decreased use by waterfowl of wetlands covered by dense stands of tall emergent vegetation and their increased use of the open areas, the shallow water sparsely vegetated with short emergents, and exposed shorelines and mud flats.

This phenomenon was evident in early studies and observations of adult breeding waterfowl (Pirnie 1935; Ward 1942; Mendall 1948; Bue et al. 1952; Dzubin 1955; Evans and Black 1956), and in later investigations (Munro 1963; Larsson 1969; Hopper 1972; March et al. 1973; Bjork 1976; Piest 1982). Preferences of dabbling ducks *(Anatinae)* for wetlands with openings in the marsh canopy or for flooded emergent vegetation of a shorter type are well documented (Marshall 1952; Glover 1956; Johnsgard 1956; Smith 1968; Drewien and Springer 1969; Poston 1969b; Hines 1975; Weller 1975a; McEnroe 1976; Bishop et al. 1979). Diving ducks *(Aythyinae)*, of course, show strong relations with open water areas (Hochbaum 1944; Siegfried 1976; Stoudt 1982).

Detailed studies have related the daily activity patterns of breeding waterfowl to the increased attractiveness of wetlands that contain an interspersion of cover and open water. Such areas may provide better food resources according to Girard (1941), McDonald (1955), Sowls (1955), Williams and Imber (1970), Courcelles and Bedard (1978), Beule (1979), Kaminski and Prince (1981b), and Murkin et al. (1982). Multiple regression analyses indicate that an increase in the ratio of open water to emergent vegetation may manifest itself in dabbling duck populations through better isolation of conspecific pairs, and may provide a cue to quality feeding habitat (Kaminski and Prince 1984).

Nest densities or hatching success may also be greater in broken versus solid stands of emergent marsh vegetation (McDonald 1955; Steel et al. 1956; Nelson and Dietz 1966; Mihelsons 1968; Ward 1968; Krapu and Duebbert 1974; Mednis 1974; Murkin 1979). The importance of openings or bare areas along shorelines for preening, resting, or waiting sites for adult waterfowl is also evident (McDonald 1955; Smith 1955; Sowls 1955; Sugden and Benson 1970; Williams

and Imber 1970; Seymour 1974; Fog 1976). Partial destruction of *Typha* spp. stands by herbicides resulted in a 300-400% increase in adult ducks per unit of shoreline (Keith 1961).

Waterfowl broods also prefer semi-open or open emergent vegetative cover, as shown by early observations and investigations (Bennett 1938; Wellein 1942; Stoudt 1944; Evans et al. 1952; Beard 1953; Berg 1956; Evans and Black 1956; Johnsgard 1956), and later studies by Keith (1961), Trauger (1967), Williams and Imber (1970), Bengtson (1971), Stoudt (1971), Sugden (1973), Whitman (1974, 1976), Mundinger (1975), Newton and Campbell (1975), Patterson (1976), and Wheeler and March (1979).

In the single instance where more broods were observed in closed stands of vegetation, Ignatoski (1966) postulated that nest success might have been higher there or that predation might have been greater in the more open areas. Studies showing that broods of dabbling ducks prefer semi-open marsh include those of Chura (1961), Perret (1962), Parnell and Quay (1965), Quame and Grewe (1970), Thompson (1974), Hines (1975), Courcelles and Bedard (1978), Mack and Flake (1980), Godin and Joyner (1981), Ringelman and Longcore (1982), Sjoberg and Danell (1982), and Talent et al. (1982). Similar results have been reported for diving ducks (Hochbaum 1944; Hilden 1964; Lokemoen 1966; Hilliard 1974; Stoudt 1982). Use of wetlands by broods increased as the number of vegetative types at the edge of the open water zone increased (Hopper 1972).

Other relations between breeding waterfowl and the physical features of their wetland habitat have been proposed. Openings in shoreline emergent vegetation may make nest sites on nearby uplands more easily accessible to hens (Mednis 1974; Mihelsons et al. 1974). Some studies indicate that waterfowl may be less susceptible to predation in more open situations (Furniss 1938; Beard 1953; Trauger 1967; Moller 1975) or that predator pressure may be buffered from waterfowl by the presence of other forms of prey in more open areas (Weller 1979). It has also been noted that a heavy buildup of marsh vegetation can make nesting islands accessible to predators (Mihelsons 1968). Rogers (1964) postulated that predation on lesser scaup *(Aythya affinis)* nests may have increased in situations where females were forced to walk, rather than swim, to their nests.

Other marsh-dwelling birds and mammals may benefit greatly from the presence of openings in marsh vegetation (Beard 1953; Seabloom 1958; Weller and Spatcher 1965; Willson 1966; Orians 1972; Vogl 1973; Gorenzel et al. 1982; Nudds 1982; Stenzel 1982). Such conditions may also result in avian communities of greater species diversity or richness (Weller and Spatcher 1965; Weller and Fredrickson 1973; Weller 1975a, 1978; Harris et al. 1981).

Biologists have often attributed decreased wetland use by aquatic birds to decreased habitat heterogeneity caused by disruption (usually a reduction) of natural ecological processes, resulting in domination by tall, robust hydrophytes in such genera as *Scirpus*, *Carex*, *Typha*, *Salix*, and *Phragmites* (fig. 1). In the absence of these processes, autogenic successional proc-

Figure 1.—A prairie wetland unburned for more than 45 years; dense stands of *Phragmites australis* (foreground) and *Typha angustifolia* (background) lie offshore from the wet-meadow zone, which is dominated by a mature stand of *Salix amygdaloides*. The area has seldom been grazed by livestock. (Roberts County, South Dakota, 6 miles southwest of Rosholt; photo by H. A. Kantrud.)

esses tend to build dense stands of such hydrophytes in most wetlands (Walker 1959; Jahn and Moyle 1964; Whitman 1976). Prairie wetlands are particularly susceptible to the establishment of monotypes because of low gradient shorelines, small differences in soils or organic matter content within basins, and the ability of many species to survive under a wide range of water conditions (Hammond 1961; Walker and Coupland 1968).

Typha spp. has spread rapidly across a major portion of the prairie pothole region. For example, Metcalf (1931) and F. M. Uhler (Patuxent Wildlife Research Center, Laurel, Maryland, personal communication, 1984) saw few *Typha*-dominated wetlands in North Dakota during 1917-25. Metcalf found only common cattail *(T. latifolia)* in North Dakota, and the species was listed only for "springy places and in the vicinity of freshwater lakes." Since then, *T. angustifolia* and the extremely robust *T. "glauca"* (a presumed *T. latifolia* x *T. angustifolia* hybrid) have become dominant in thousands of prairie wetlands whose salinity ranges from fresh through slightly brackish (Stewart and Kantrud 1971).

Typha spp. is well-adapted to form monotypes (Linde et al. 1976). *Typha* seeds germinate under a wide range of water depths (Weller 1975b) and tolerate a wide range of soil types (Dean 1933). Older plants prevent competition from younger plants by autotoxicity (McNaughton 1968). Because shoot death in *Typha* spp. occurs late in the growing season, this plant's competitive advantage over other species is probably enhanced (Davis and van der Valk 1978). A process of self-thinning allows individual, *Typha* plants to grow large; decomposition of these large plants may take as long as 2 years (Mason and Bryant 1975). Mechanical control of *Typha* spp. is difficult and expensive (Nelson and Dietz 1966; Weller 1975b).

When tall, robust emergents such as *Typha* spp. dominate a wetland, drastic environmental changes occur. Less insolation of marsh soils and the water column caused by tall emergents and their litter may reduce or eliminate other species of plants in the understory (Bennett 1938; Buttery and Lambert 1965; Spence and Chrystal 1970; Vogl 1973) or lower productivity (Willson 1966). Submerged plants, in particular, require water of sufficient depth to reproduce (Anderson 1978; Courcelles and Bedard 1978), and the buildup of litter and organic material from emergent species may reduce water depth or elimi-

nate shallow water areas (Ward 1942; Walker 1959; Hammond 1961; Ward 1968; Beule 1979). Buildup of litter and the shading effect also may result in lower soil or water temperature and slower rates of plant decomposition (Willson 1966; Godshalk and Wetzel 1978). Various emergent species may decompose at different rates as the result of differences in species composition of macroinvertebrate populations (Danell and Sjoberg 1979). Thus the development of monotypic stands of emergents may effectively remove some of the variation in decomposer organisms that could act to maintain or increase vegetative heterogeneity.

Management of Wetland Vegetation for Waterfowl

Burning

Komarek (1976) stated that the fire ecology of wetlands was sorely in need of scientific study. General references (Kozlowski and Ahlgren 1974; Wright and Bailey 1982) indicate that burning of marsh vegetation releases nutrients, opens the canopy and detrital layer, and allows for increased insolation and resultant earlier warming of bottom soils. Biological productivity usually increases following fire, even though plant species composition may be altered. Little change in species composition usually occurs when perennial species with meristem at or below ground level are burned during their dormant period.

Fires were common in prairie wetland vegetation in the early 19th century, as evidenced by the accounts of early traders and travelers. For example, in 1803 Henry and Thompson (1965) recorded fire rushing through "low places covered with reeds and rushes." In 1858 or 1859, Boller (1972) saw a large conflagration spread for many miles after being set by American Indians in "dry rushes in the prairie bottoms." Denig (1961), writing about his experiences during 1833-54, noted that fire would sweep over ice through wetland vegetation.

Impacts on Vegetation

Little is known about the environmental effects of fire in prairie wetlands. Much of the available information is obtained from general observations on wetlands where the fire

frequency or season was unknown, or from fires set in a variety of vegetation types, usually on a nonexperimental basis. Hence, the results are often inconsistent and of minimal predictive value. Early studies by Lewis et al. (1928) indicated the changes in a few plant communities in central Alberta that could be expected in the presence or absence of a burning regime. Furniss (1938) noted that heavily lodged stands of *Typha latifolia* and *Scirpus validus* could be removed by fire in Saskatchewan wetlands. Ward (1942) found that dense beds of *Phragmites australis* in Manitoba wetlands could be opened up by either spring or late summer burns, but that only late summer burning killed the "roots" (rootcrowns). Grange (1949) observed that smartweeds *(Polygonum* spp.) disappeared because of competition from *Carex* spp., *Typha* spp., *Phragmites australis,* and various grasses. He stated that burning was probably the only effective method of stimulating smartweed growth in Wisconsin wetlands. Truax and Gunther (1951) used fall and winter burns to control undesirable vegetation at Horicon Marsh, Wisconsin. Annual burning was used to maintain the *Carex* spp. community in other Wisconsin wetlands (Thompson 1959). Tester and Marshall (1962) saw little change in species composition of wetland vegetation when Minnesota marshes containing low fuel volumes were burned. Smeins (1965) listed a few wetland plants found in North Dakota marshes with a history of burning. Schlichtemeier (1967) successfully removed dead stems of *P. australis* and *Scirpus* spp. with a winter burn, even though snow covered the bases of the plants. Vogl (1967) found burning generally favorable as a means of controlling woody plant invaders in Wisconsin wetlands. Smith (1969) stated that *Typha* spp. could quickly be destroyed by fire in Alberta wetlands. Beule (1979) concluded that burning was an ineffective control for *Typha* spp. in Wisconsin wetlands unless the peat layer was also burned. Gorenzel et al. (1981) found that fire failed to kill *Typha* spp. and *S. americanus* in a Colorado wetland. Thompson (1982) studied the seasonal effects of burning *P. australis* stands in a Manitoba wetland, and concluded that the changes in species composition and productivity produced by fall burns were intermediate between those produced by spring or summer burns.

In seasonal prairie wetlands, Stewart and Kantrud (1972) thought *Polygonum coccineum* increased after burning. However, Millar (1973) found no change in stands of *Carex ath-*

*erodes, Scolochloa festucacea,*and *Eleocharis palustris* after repeated burning, which indicates these common plants of seasonal wetlands are extremely fire tolerant.

The aforementioned studies and observations do not provide managers with definitive, quantifiable information needed to formulate burn prescriptions in prairie wetlands. Research on prescribed burning for these wetlands for wildlife production was urged by Ward (1968) and Weller (1978), but to date almost all marsh burning for improvement of Waterfowl habitat has been done on migration or wintering areas (Sanderson and Bellrose 1969; Rutkowsky 1978).

Effects on Breeding Waterfowl

There is little substantive information about fire as it affects use of prairie wetlands by breeding waterfowl. Bennett (1938) and Furniss (1938) probably were the first to postulate that some benefits to breeding waterfowl could accrue from marsh burning. Bennett recommended shoreline burning to open dense stands of emergents to increase foods for blue-winged teal *(Anas discors),* whereas Furniss noted that crow predation on Saskatchewan duck nests may be less in marshes where heavily lodged, old-growth *Typha* spp. and *Scirpus* spp. stands were opened up or rejuvenated by fire. Cartwright (1942) suggested that burning dense, matted vegetation in Manitoba meadows would improve use by nesting ducks. Ward (1942) stated that burned openings in dense stands of *Phragmites australis* were heavily used by breeding ducks at the Delta Marsh, Manitoba. Grange (1949) noted that plants that produced seeds readily eaten by ducks were easily lost to competition from other plants and considered burning the only effective way to control plant succession in Wisconsin wetlands. In South Dakota, Evans and Black (1956) noted that burning often improved use of wetlands by pairs of breeding waterfowl. Drewien and Springer (1969) observed that many burned wetlands lacked roosting cover in the spring, but that overall use of the wetlands by breeding pairs was not much affected.

Only a few experimental marsh burns have been conducted to study the effects on breeding waterfowl. Ducks showed increased use of winter-burned stands of *P. australis* and *Scirpus acutus* in wetlands in the Nebraska Sandhills (Schlichtemeier 1967). Ward (1968) found that, in a Manitoba wetland, fire opened up old stands of *P. australis* that formerly were almost

devoid of duck nests and stimulated growth of *Scolochloa festucacea,* which supported highest duck nest densities. However, duck nest success was low the first year after a fire on low, *Poa pratensis* prairie in Iowa (Messinger 1974). A more detailed study was conducted by Bjork (1976), who observed that, in a Swedish wetland "severely damaged" by overgrowth of *Phragmites australis* and *Carex acuta,* burning and mechanical methods of vegetation control resulted in much greater use of the area by breeding ducks, probably because of the presence of higher populations of chironomid insects. Prescribed burning of *P. australis* and *Typha* spp. during the dormant season is practiced on some National Wildlife Refuges (fig. 2).

In the absence of water control, burning of vegetation in wetlands that naturally retain water only seasonally probably cannot be justified as a management practice for breeding waterfowl (Diiro 1982). Diiro found that increased early-season productivity of plants and invertebrates in basins burned the previous fall was offset by a general scarcity of water caused by the reduced snow-trapping ability of burned vegetation. In addition, snow accumulations tend to crush the softer vegetation

Figure 2.—Prescribed spring burn being used to open a dense stand of *Phragmites australis* on the J. Clark Salyer National Wildlife Refuge. (Bottineau County, North Dakota, 4.5 miles southeast of Westhope; photo by R. Giese.)

found in seasonal wetlands, causing them to maintain an open or semi-open aspect during most springs. However, I believe that in pristine times vegetation in such wetlands would have burned more frequently than that found in more permanent wetlands. Long-term experiments on the effects of fire in the less permanent types of wetlands are needed.

Grazing

Much more is known about the effects of grazing than of burning on wetland plant communities. Unless unusually severe, grazing results in greater plant species diversity and the development of more intricate patterns and sharper boundaries among plant communities (Bakker and Ruyter 1981). Livestock trampling may affect the height and density of wetland vegetation more than consumption (Hilliard 1974). Overgrazing may cause a decrease in primary production (Reimold et al. 1975), an increase in water turbidity (Logan 1975), and areas devoid of vegetation (Bassett 1980), as shown in figure 3. Adaptations of wetland plants to grazing include nodal rooting and unpalatability (Walker 1968; Walker and Coupland 1968). Marshes often show greater vegetative response to grazing than upland communities (Bassett 1980). Lists of species that increase with, or are tolerant of, grazing in wetlands in or near

Figure 3.—Long-term overgrazing can destroy nearly all emergent vegetation in those shallow prairie wetlands having firm bottom soils. (Dickey County, North Dakota, 9 miles northwest of Forbes; photo by H. F. Duebbert.)

the prairie pothole region have been published by Evans et al. (1952), Smith (1953), Harris (1954), Smeins (1965), Dix and Smeins (1967), Walker and Coupland (1968), Stewart and Kantrud (1972), and Millar (1973).

Effects on Breeding Waterfowl

Most active management of waterfowl habitat through grazing by domestic livestock occurs on the wintering grounds, where the usual goal is to increase the availability of seeds of annual food plants (Griffith 1948; Neely 1967; Ermacoff 1968; Sanderson and Bellrose 1969). The effects of grazing on the quality of wetland habitat used by breeding waterfowl have received much attention during general investigations but little by experimental design. Early work by Bennett (1937) and Furniss (1938) on wetlands in Iowa and Alberta, respectively, indicated that overgrazing degraded habitat for ducks that nested along marsh borders or over water, but that nest density increased and egg predation by crows was less when densely vegetated shorelines were opened up by livestock. Sowls (1951) noted that ungrazed edges of wetlands attracted few breeding ducks and stated that ducks might increase if such areas were moderately grazed. Disturbed shorelines that would otherwise have supported dense growths of *Typha* spp. and *Scirpus* spp. probably supported higher densities of dabbling ducks in South Dakota stock ponds (Bue et al. 1952). Glover (1956) concluded that light-to-moderate grazing of shorelines after 1 July would not harm their value to waterfowl. Studies of man-made wetlands confirmed the deleterious effects of overgrazing on use of these wetlands by breeding ducks (Shearer 1960; Uhlig 1963). A study conducted in South Dakota (Sand Lake National Wildlife Refuge, unpublished annual reports, 1957-61) reported increased use of grazed shorelines by breeding ducks, especially green-winged teal *(Anas crecca)*, northern pintail *(A. acuta)*, and blue-winged teal. Salyer (1962) found that grazing was less harmful to breeding ducks when water areas increased in number and depth. Light grazing was recommended by Munro (1963) to help open *Typha* stands, thereby improving prairie wetlands for breeding waterfowl. Poston (1969b) postulated that light-to-moderate grazing would result in near optimum conditions for northern shoveler *(A. clypeata)* on Alberta wetlands. The moderately grazed portion of the wetland shown in figure 4 represents an

interspersion of cover and open water that is attractive to waterfowl.

Drewien and Springer (1969) were probably the first to report that breeding ducks move to roost in more heavily vegetated wetlands at night. These wetlands contained patchy, moderately dense stands of *Carex* spp., *Polygonum coccineum, Scirpus* spp., *Scolochloa festucacea,* and *Typha* spp. The authors believed that lack of roosting cover did not limit densities of blue-winged teal on their South Dakota study area; sufficient roosting cover was always present because of other land-use practices, and even the overgrazed wetlands grew acceptable amounts of cover as the season progressed. During the day, the teal were found at higher densities on idle than on grazed wetlands; however, the authors inferred that this related to the proximity of upland nesting cover to the idle wetlands, rather than to differences among wetlands.

Kirsch (1969) found that pair use was lower on grazed North Dakota wetlands, but the differences between grazed versus idle wetlands were not significant. Cattle disturbance of duck

Figure 4.—Moderate cattle grazing created the semi-open and more diverse plant community shown on the right side of the fence; the portion on the left remains idle. (Stutsman County, North Dakota, 2.5 miles east-southeast of Woodworth; photo by K. F. Higgins.)

nests was thought to be important during the study. Gjersing (1971) found high losses of duck nests due to livestock trampling around Montana reservoirs when the nests were within 7 yards of the shoreline. Winter grazing in Utah wetlands seemingly did not affect nesting dabbling ducks, but probably was harmful to divers (Hilliard 1974). In Denmark, Moller (1975) recommended grazing of wetlands during the nonbreeding season, and Fog (1976) believed that great portions of ungrazed marshes were lost to breeding ducks by the invasion of *Phragmites australis.* By using multiple regression analysis, McEnroe (1976) found that the percentage of shoreline grazed on natural wetlands was positively related to density indices (pairs per wetland) for the mallard *(A. platyrhynchos),* gadwall *(A. strepera),* and blue-winged teal; however, intensity of grazing was negatively associated with densities of blue-winged teal and redhead *(Aythya americana).* A similar analysis of dabbling duck use of man-made wetlands in South Dakota showed species-specific preferences associated with differences in vegetation height, density, or diversity caused by grazing (Flake et al. 1977). The northern shoveler made greatest use of pastured wetlands in England (Thomas 1980). The highest concentrations of breeding canvasback *(A. valisineria)* seen by Stoudt (1982) in a Manitoba study area were usually associated with pastured wetlands containing open or half-open surfaces and stands of *Scirpus acutus.*

Waterfowl Broods and Grazing

Relations between grazing and use of wetlands by waterfowl broods have also received some attention. Girard (1941) noted that broods would benefit if wetland shorelines in Montana were protected from overgrazing. In Manitoba, the *Typha*-choked wetlands containing less than 10% open water received almost no use by duck broods (Evans et al. 1952). A history of light to moderate spring and fall grazing resulted in the open *Carex* spp. and *Scolochloa festucacea* habitat which was preferred by broods; ponds with broken stands of *Scirpus acutus* resulting from moderate to heavy grazing throughout the growing season were also extensively used. Broods were far more abundant on South Dakota livestock ponds with grassy shorelines than on those with mud shorelines created by overgrazing (Bue et al. 1952). Short emergent growth in sparse stands caused by grazing also provided the best brood habitat

on eastern Montana stock ponds (Smith 1953). Harris (1954) observed that heavily grazed areas dominated by *Scirpus* spp. and *Juncus* spp. received the most use by broods in Washington potholes. Overgrazing, especially of small wetlands, created unsuitable brood habitat in South Dakota (Evans and Black 1956). Keith (1961) noted a large increase in brood density after partial destruction of *Typha* spp. stands by herbicides on Alberta impoundments, and he recommended combining grazing and herbicide applications to rejuvenate marsh edges for ducks. In Colorado, broods used lightly-to-moderately grazed wetlands far more than either moderately-to-heavily grazed wetlands or those that lay idle (Hopper 1972). Evans and Kerbs (1977) identified South Dakota impoundments having gently sloping shorelines and light use by livestock as water areas that would develop the natural vegetation structure preferred by broods. Nonetheless, if such wetlands contain appreciable amounts of *Typha* spp., its influence on brood use may be negative (Mack and Flake 1980). Canvasback broods in Manitoba reached highest densities in pastured wetlands containing less than 33% emergent vegetation (Stoudt 1982). Hudson (1983) found that duck brood densities were positively related to the amount of vegetation in Montana livestock ponds, but no ponds totally covered with emergents were censused, and all ponds were grazed.

Invertebrate Food and Grazing

Only a few investigators have mentioned response by invertebrate animals to herbage removal by livestock. Munro (1963) stated that grazing of *Typha*-dominated prairie wetlands would increase the planktonic algae that are the primary foods of invertebrates. Hopper (1972) believed that light-to-moderate grazing of flooded emergent vegetation would provide invertebrate foods for duck broods and also allow them easier access to shoreline feeding areas. Some very large invertebrates in salt marshes (such as crabs) may decrease under heavy grazing, but recovery is probably very rapid once grazing pressure is lessened (Reimold et al. 1975). Decreases of invertebrate animals caused by grazing of wetlands probably occur only when livestock are present in enough numbers to destroy aquatic vegetation (Logan 1975).

Invertebrates have been known to be important in the nutrition of breeding ducks since the early 1960's (Voights 1973).

Indeed, invertebrate numbers and taxa may surpass all other measured physical and biological variables as indicators of wetland quality for breeding ducks (Joyner 1980), although it may be necessary to determine the behavior and distribution of the invertebrates in order to accurately predict which microhabitats will attract feeding ducks (Joyner 1982). Management of invertebrates for waterfowl was reviewed by Schroeder (1973) who recommended manipulation of cover through water control, grazing, and burning. He cautioned that such manipulations should favor a good interspersion of cover types without creating excessive siltation, undue fluctuations of water levels during the nesting season, extensive reductions in plant abundance and diversity, and contamination of water supplies by toxic chemicals. When the invertebrate resources of prairie wetlands are manipulated by mechanical methods (Murkin 1979; Kaminski and Prince 1981a, 1981b), treatments are expensive and the response of breeding waterfowl is often small or of short duration.

Research Needs

The prairie wetland complex has been severely degraded. Thus, it is too late to determine precisely the natural plant associations and structural types of vegetation historically preferred by waterfowl species during different phases of the breeding cycle. Other than drainage, cultivation, and siltation, the worst problem now is decreased waterfowl use caused by the regression of many of the semipermanent wetlands toward *Typha* spp. monotypes, and the encroachment of woody plants such as *Salix* spp. The problem is especially noticeable in the eastern portion of the prairie pothole region where livestock production has decreased, and many wetlands now lie idle. The problem is no less severe on much of the publicly owned land devoted to waterfowl production. In this instance, wetland managers seldom have the time, equipment, or manpower to properly manipulate vegetation on wetlands. More importantly, managers lack the information needed to obtain desirable, predictable results. However, much useful information can still be obtained by studying existing wetland complexes that are subjected to various land uses or combinations of uses.

Much remains to be learned about the physical and biological environments preferred by species of breeding waterfowl during their seasonal and daily activities. This should be ascertained from existing wetland complexes that are in the highest state of natural preservation. Knowledge of the preferred feeding, nesting, loafing, and roosting areas, and reactions and adaptations of the birds to climatic changes and predator pressure would aid in evaluating future experiments in marsh management.

Armed with a better understanding of the life history of individual species, burning and grazing treatments should be applied individually and in combination to selected prairie wetlands of various classes, salinity subclasses, vegetative types, and sizes that are most important to the common species of waterfowl.

Burning and grazing experiments should stress seasonality, frequency, and intensity, and the interactions of these variables should be measured. Effects of cover level (amount of emergent cover) should be separated, if possible, from the effects of cover configuration (size of clumps, shape of clumps, distances between clumps), as suggested by Murkin et al. (1982). The investigations should be long-term because of the drastic climatic fluctuations in the prairie pothole region. It would also be helpful if treated wetlands were dispersed over a broad geographical area to allow for differences in precipitation across the region. Studies should not be limited to the effects on waterfowl, but include the response of the vegetative community and the invertebrate food organisms of waterfowl. The response of other wetland vertebrates (primarily herbivores) to higher nutritive quality of burned wetland vegetation should also be measured as recommended by Smith et al. (1984).

Finally, changes to the physical and chemical environment should be monitored to increase our knowledge of causative factors involved in the biotic responses observed, and for the potential predictive values of abiotic factors in future marsh manipulations. Basic measurements should include winter snow accumulations, fluctuations in water depth and temperature among wetland vegetation zones, insolation, and standard water quality parameters.

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U.S. Department of Agriculture
Forest Service

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